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Volume III

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16. ABSTRACT

This study considered five dominant dimensions of the status of domestic water: quality, quantity, availability, cost and affordability. Rural residents were asked about health effects but the results were modest in that very few rural residents reported adverse health conditions which they associated with the water supply.

With enactment of the Safe Drinking Water Act of 1974, Congress set in motion two major efforts to develop systematic, current data on rural water supplies across the nation. First, in response to growing concern with the quality of drinking water and its effects on human health, the Safe Drinking Water Act provided for a uniform, national set of water quality standards and extended the monitoring and regulatory responsibility of the US Government over smaller water supplies. Second, the Act mandated a one-time national statistical assessment of the current status of rural domestic water characteristics. This document fulfills that mandate.

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VII

Water Supply Systems

The emphasis in the NSA report to this point has been on rural households and their water supplies. The types of supplies providing water to households were considered in Chapter IV, and the status of the supplies was discussed in Chapter V. In this chapter, the focus is expanded to take into account various technical aspects of the supplies and their organizational features. As explained in Chapters II and IV, the supply is defined as the set of physical facilities by which water is extracted from the source, treated, and transported to the household. The supply also refers to the water as it reaches the household—that aspect of the supply which has so far received the most attention in this report. On the other hand, the system refers to the water supply in its social and organizational setting, and also includes the supply's technical components.

Since the system has a strong influence on the size and technical features of the supply, this chapter is structured according to types of systems. The systems are typified according to the three major system-size categories—individual, intermediate, and community systems. As noted in Chapter II, these three categories are used consistently in this report in the belief that each encompasses certain specific characteristics. In addition, each category is subject to a different set of regulatory and financial provisions.

These three types of systems are described here in terms of overall as well as unique characteristics. The overall characteristics include organizational and social aspects which range from system ownership to water quality. Overall characteristics also include selected details about technical aspects of the systems, ranging from the type of well construction to the adequacy of protection from runoff. Unique characteristics of intermediate and community systems include aspects such as the number of metered connections and the types of water processing and treatment facilities.

The primary focus of this chapter is on the physical and technological characteristics of water supply. Selected organizational features related to these, like testing, number of operators, and metering, are also discussed. Chapter VIII covers the financial and economic aspects of these systems. Information in Chapter VIII builds from the results presented here. The two chapters complement one another. It is necessary to keep in mind that the characteristics described in both of these chapters are always for systems providing the major domestic water supply in rural households.

RURAL WATER SYSTEMS

At the time of the NSA survey, there were 8,765,000 individual systems, 845,000 intermediate systems, and 34,000 community systems in the rural US. This numerical order changes, however, when the consideration becomes not total numbers of systems, but total numbers of households served by systems. That is, although individual systems were by far the most numerous, intermediate and community systems served proportionately more households, since each of those systems had multiple connections, whereas each individual system had only one connection. Specifically, community systems served 10,981,000 households, compared to 8,765,000 households served by individual systems and 2,228,000 households served by intermediate systems (see Figure VII-1).

In previous chapters, the presentation of results was for the weighted number of rural households estimated to exist in late 1978 for the nation and each of the subnational categories. These weighted estimates were based on the sampling design which generated the 2,654 rural households actually investigated, as indicated in Chapter II. Likewise, the following presentation of results for water supply systems, in each category, was based on estimates of the weighted number of systems providing water to rural households in late 1978. Because of the nature of the sampling design, the actual number of individual systems investigated was 1,193, which projects to a weighted number of about 8,765,000; the actual number of intermediate systems studied was 294, projecting to a weighted number of about 845,000; and the number of community systems observed was 800, which was projected to represent an estimated 34,000 community systems. The lack of proportionality between the number of systems of each type actually observed and the projected weighted number of systems of that type is a function of the sampling design and ratio weighting scheme used in the NSA.

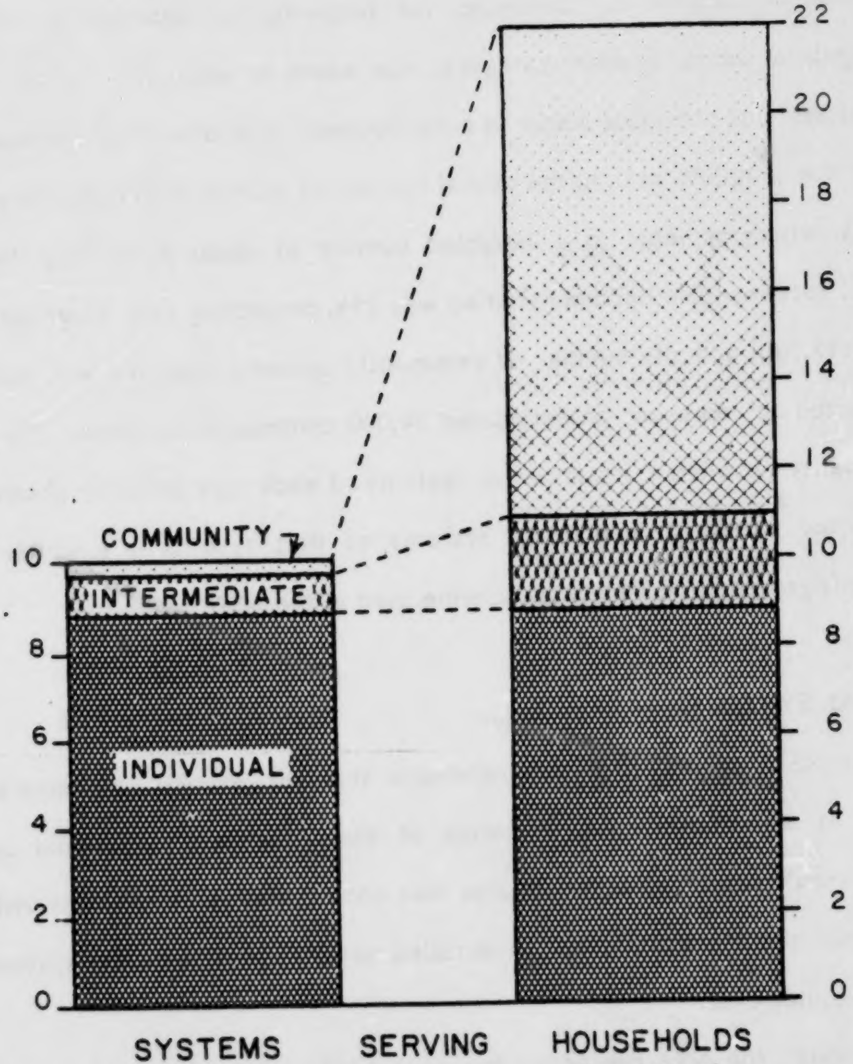
INDIVIDUAL SYSTEMS

The NSA was the first comprehensive study of individual systems in rural America. It was known that, in terms of sheer numbers, individual systems dominated rural water delivery. It also was known that these systems utilized a variety of sources and equipment. A detailed national profile of the systems was not available, however.

Although the NSA presented the opportunity to develop such a profile, a detailed examination of all technical features of individual systems would have been far beyond the scope of the study. Instead, the emphasis here was placed on aspects which appeared to be related to a rural supply's quality, quantity,

Figure VII-1

Comparison of Number of Systems and Number of Households Served in Rural America



availability, or general effects—four of the key factors used to define the status of rural water supplies (see Chapter V). Comparable aspects of intermediate and community systems were investigated to allow comparisons among types of systems. In line with the historical development of the Safe Drinking Water Act, primary emphasis was on features related to water quality.

In the discussion which follows, general reference features—source, ownership, and age of the system (or the length of time the system had served the household)—are taken up first. Against this background, relevant engineering features which usually are external to the household are examined, and compared according to type of source. This consideration leads back to general considerations such as the methods of bringing water into the household, the types of water processing and treatment devices attached to the system, free professional advice offered to users, and the history of laboratory testing of water quality.

In summary, the profile of individual systems is set out so that certain overall features are apparent. Then engineering features which generally are external to the household and which are related to selected aspects of water supply (principally to water quality) are described. Next, the system is traced from the external engineering features to considerations within the structure which seem relevant to the status of rural water supplies. Finally, the household experience with laboratory assessment of water quality is investigated. The possible relationships between the various elements in the system—between engineering and water quality, for example—are explored in later chapters.

General reference features of all individual systems

As expected, individual systems in rural America were supplied mostly by groundwater. Fully 93.2 percent of the 8.8 million individual systems—all those with wells or springs—had a groundwater source (Table VII-1). Groundwater was particularly prevalent as a source for individual systems, which often used wells,

Table VII-1

Source, Ownership, and Length of Service Among Individual Water Systems

	Nation	
Characteristic	Number of Systems	Percent of Systems
Source		
Groundwater	8,168,000	93.2
Precipitation	133,000	1.5
Surface water	93,000	1.1
Purchased bottled, or hauled	371,000	4.2
Total	8,765,000	100.0
Ownership		
Individual	8,505,000	97.0
Private firm	101,000	1.1
Public	69,000	0.8
Cooperative	16,000	0.2
Indian tribe	16,000	0.2
No owner	18,000	0.2
Other	41,000	0.5
Total	8,765,000	100.0
Number of years served by system		
Up to 5	3,886,000	44.3
6 - 10	1,586,000	18.1
11 - 20	1,632,000	18.6
21 - 50	1,556,000	17.8
More than 50	100,000	1.1
Could not be determined	5,000	0.1
Total	8,765,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

but it was somewhat less common as a source for community systems, as reported later in this chapter. About 2 percent of all individual systems—those with cisterns—had precipitation as a source; about 1 percent had a surface water source. The balance had purchased bottled water, or hauled supplies (see Chapter IV for definitions), and the sources for those supplies could not be determined.

Also as expected, nearly all individual systems—97 percent—were owned by individuals. The owners often were members of the household, but some systems (1.2 million, or 14.1 percent of all individual systems) were owned by individuals who were not part of the household. A few systems—about 1 percent of the total—were owned by private firms. The remaining 2 percent of systems showed a variety of arrangements, ranging from no ownership to ownership by a cooperative (see Table VII-1).

Age was thought to be an important attribute of the system, but there was a limitation in the NSA's capacity to determine the age of some individual systems. Because of this limitation, the NSA determined the length of time in which the respondent had been served by the system; this information was collected at all households, regardless of what type of water supply system they had. Length of service was important as a measure of the respondent's direct knowledge of the household water system, but for individual systems not using wells it also provided supplementary data on system age (a minimum age of the system). Based on the survey results, the median number of years during which households were served by individual systems (for those systems for which information could be obtained) was 7.1 years. As seen in Table VII-1, the majority of systems had served households for ten years or less. Whereas a considerable proportion of systems (about 19 percent) had provided water to households for more than twenty years, only a small proportion (1.1 percent) had provided water for more than 50 years. The longest period of service (for 0.1 percent of systems) was 75 years.

External engineering features of individual systems

The engineering features of individual systems can be divided conveniently into those which usually are external to the household and those which often are more closely associated with the household. Here, the external features are described. Those features vary prominently according to the supply source, so they are categorized here according to source. Thus, the features for wells and springs, which are dependent on groundwater sources, are discussed first. The features for cisterns, which are dependent on precipitation, are examined next. Finally, the features for surface water supplies—which are the least common type of supplies for individual systems—are investigated. Features of individual systems using purchased bottled or hauled water are not considered since the sources could not be determined.

Several qualifying comments are necessary before presentation of the NSA findings. First, although a distinction is made between external and household-related engineering features, the distinction admittedly is arbitrary. For example, some wells are drilled near or beneath the household basement, and nearly all of the supply equipment is in or under the house. On a more fundamental level, operation of the system depends on integrated functioning of all of the equipment, wherever located, and the NSA distinction is clearly an investigative convenience rather than an engineering imperative. Second, only selected engineering features are considered. Since the main historical motivation for national concern about drinking water has been water quality (see Chapter V), external engineering features studied in the NSA were related primarily to sanitary and pollution control measures. However, some of the features were relevant to other considerations as well, such as supply quantity or cost. Finally, the information about the engineering features was obtained in part by questioning of household respondents, in part by inspection of supply arrangements by interviewers. Thus, the information provides a profile of the situation in rural America without detailed reference to official standards regarding the engineering features. For example, most states have statutes to regulate a number of well-construction features,[1] and sizable proportions of rural wells studied in the NSA apparently were not in compliance with all of the standards. In fact, some of the wells may have been constructed before the standards went into effect. In any event, it was beyond the scope of the NSA to evaluate wells, or other supplies, by comparing the NSA findings to applicable regulatory requirements regarding construction standards.

Individual wells

Of the 8.8 million individual systems in rural America, 90 percent (a total of 7.9 million) relied on wells. Although wells and springs used the same source (groundwater), there were only 275,000 springs in rural America, as discussed presently. Because of the recognized prominence of individual systems with wells, special efforts were made to obtain considerable information about their external engineering features and general layout. The profile for individual well features and layout are presented here by describing first the general siting and wellhead arrangements of the supply. Next, construction features of the well shaft are discussed—features which are basic to well design and to considerations about the status of rural supplies. Then, a series of considerations are taken up related specifically to sanitary aspects of the system design.

— Sites of individual wellheads

In terms of the wellhead arrangements, there were various possible configurations ranging from old open wells which were exposed to most environmental elements to modern wells which were sealed against environmental incursions. The arrangements were grouped in three general classifications in the NSA—wellheads which terminated above ground, either with or without protective covering such as a shed or roof (Figure VII-2); wellheads which were in a well pit (Figure VII-3); and

Figure VII-2
Pump House for Well

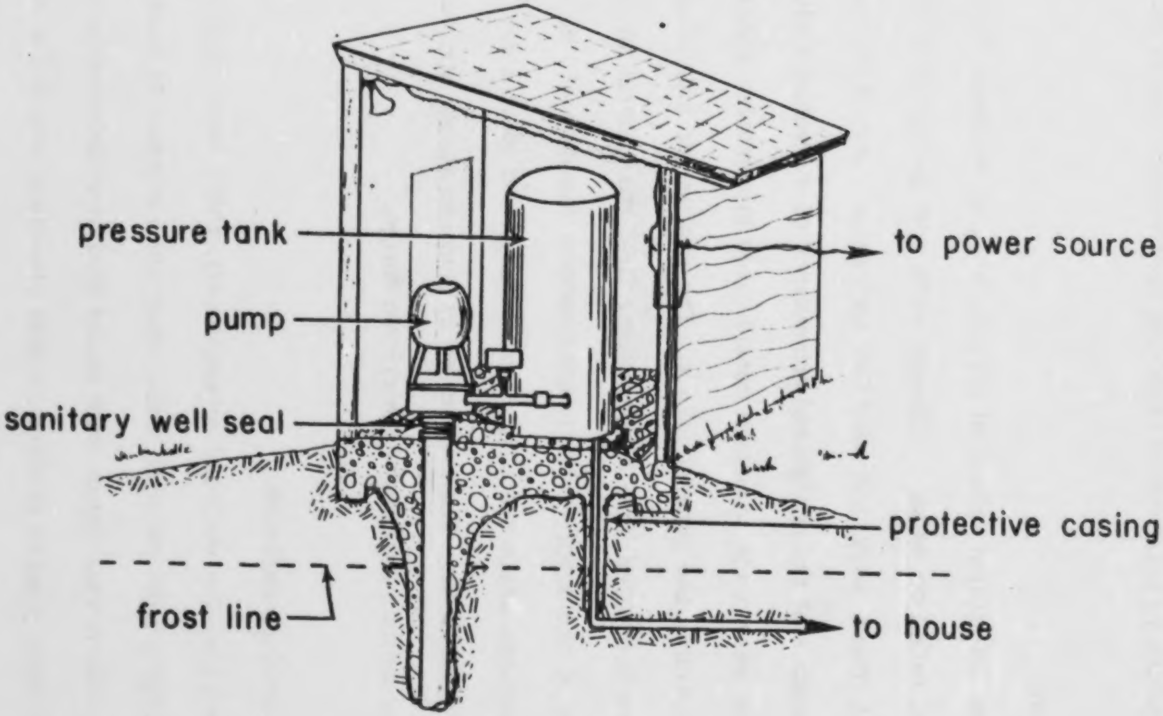
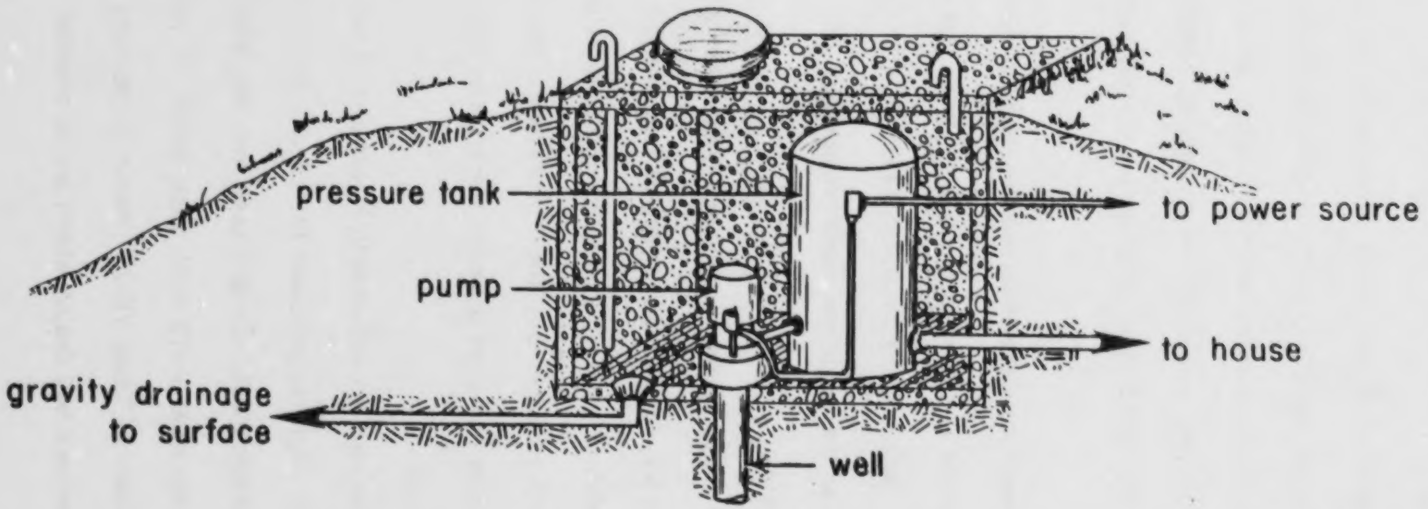

pressure tank
pump
sanitary well seal
frost line
to power source
protective casing
to house

Figure VII-3
Well Pit


pressure tank
pump
gravity drainage
to surface
well
to power source
to house

wellheads which were entirely underground—buried wells (Figure VII-4). Each classification was relevant to certain operating characteristics of the wells, but the focus of the NSA was on the relation of these characteristics to the sanitary integrity of the system.

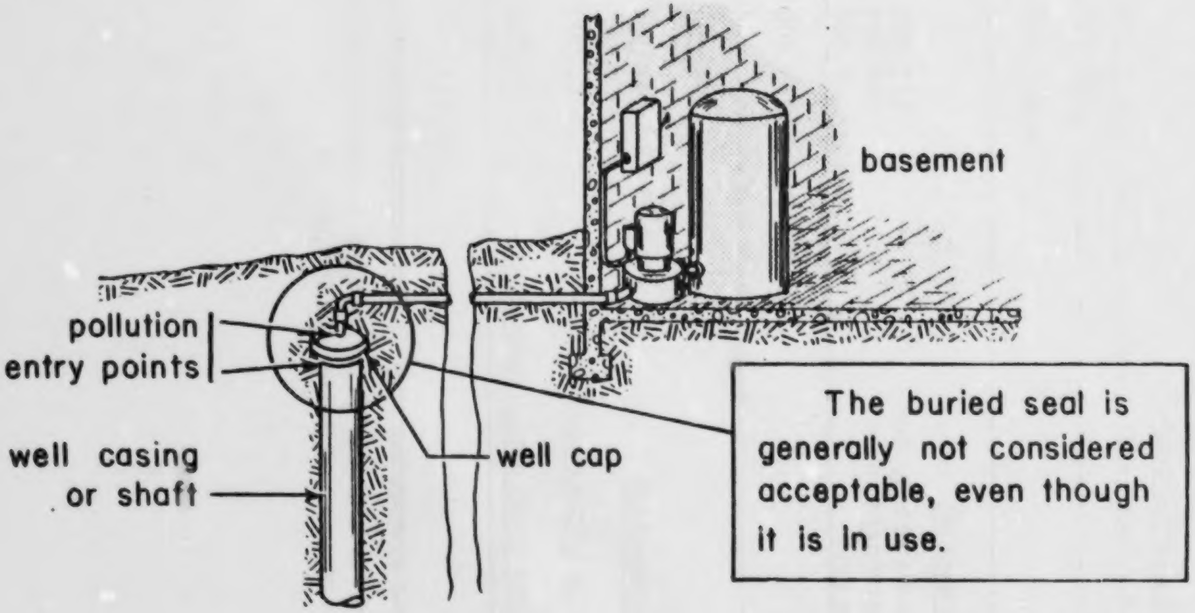
As can be seen in Table VII-2, roughly six of ten individual wellheads terminated above ground, generally within some structure such as a pumphouse. The presence of a structure implied some protection from natural elements. Such protection alone, of course, would not be enough by itself to assure a contamination-free well, and therefore other engineering considerations were important, as discussed below.

Other considerations were involved for the 17.6 percent of individual wells in well pits. The well pit is a special facility to house the wellhead, including the pumping equipment. Water and contaminants can accumulate in the pit and then seep into the supply, so the pit is not recommended by the EPA, and it is actually prohibited in some states.[2]

The pollution-trapping characteristic inherent in well pits can be modified in several ways. One way is to install a cover over the pit to keep out debris and precipitation. The NSA revealed that 58 percent of individual well pits (a total of 808,000) did have such covers—but the covers were not watertight. About 40 percent of the well pits had covers which were watertight; 2 percent of the well pits had no covers at all.

Another of the various antipollution features of well pits is a drain to free the pit of water which might accumulate from leaky covers or from leaky pipes. If the water were not drained off, it might seep into the well. The NSA showed that of the 1.4 million individual wells with pits, about 55 percent (762,000) had no drains (data not included in Table VII-2). About 31 percent had drains which led to open ground, and 9 percent had drains which led to another drainpipe or to a sewer

Figure VII-4
Buried Seal


basement
pollution entry points
well casing or shaft
well cap

The buried seal is generally not considered acceptable, even though it is in use.

Table VII-2

Wellhead Arrangements for Individual Wells

Classification	Nation Number of Systems	Nation Percent of Systems
Terminated above ground		
Protected (by shed, roof, or other structure)	3,510,000	44.5
Uncovered	1,187,000	15.0
Subtotal	4,697,000	59.5
Situated in well pit		
Pit without watertight cover	808,000	10.2
Pit with watertight cover	558,000	7.1
Pit with no cover	27,000	0.3
Subtotal	1,393,000	17.6
Buried	1,387,000	17.6
Situated in household	293,000	3.7
Miscellaneous arrangements	28,000	0.4
Arrangements could not be determined	96,000	1.2
Total	7,893,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

pipe. For about 5 percent of the well pits, information about pit drainage could not be obtained.

Again, as seen in Table VII-2, wellheads which did not terminate above ground, or which were not in pits, most often were buried (17.6 percent). Very few wellhead arrangements were inside the dwelling-unit structures (3.7 percent). In some instances, miscellaneous arrangements were used, or the arrangements could not be determined.

In summary, individual wellheads most often terminated above ground —frequently under protective covering. Less than one-fifth of wellheads were in well pits, which are not favored by authorities because they are easily contaminated. Less than one-fifth of the wellheads were entirely buried. The predominant situation, then, was one which featured wellhead equipment at a site separate from the dwelling structure—usually at surface level, but sometimes in a well pit.

— Construction of individual wells

Past studies and general experience have shown strong relationships between the type of well construction and key aspects of rural water supplies. The type of construction of individual-system wells is outlined here, and the construction characteristics are compared in later chapters with certain supply aspects, including quality, quantity, and availability of water.

As seen in Table VII-3, nearly six of every ten individual wells were drilled, commonly by using percussion or rotary drilling, as shown in Figure VII-5. A much smaller proportion of wells (12.5 percent) were dug (Figure VII-6), and a similar proportion were driven (by pounding a preassembled pipe system into the ground —see Figure VII-7). Some individual wells were bored (usually by using earth augers—see Figure VII-8); a few wells were jetted (by applying a stream of high pressure water which forms a hole for the well point and pipe—see Figure VII-9).

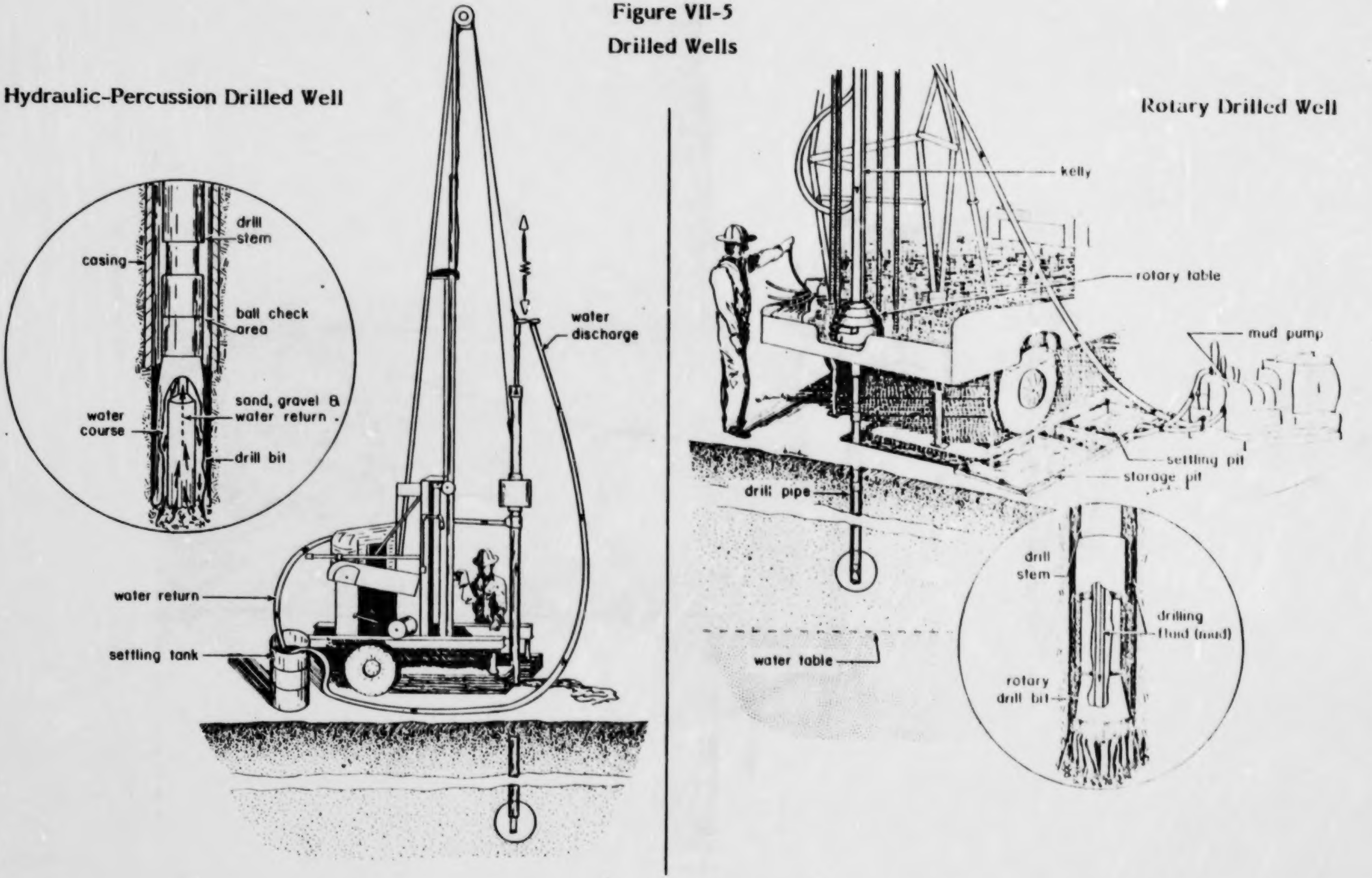
Table VII-3

Construction of Individual Wells

Type of Construction	Nation Number of Systems	Percent of Systems
Drilled	4,560,000	57.7
Driven	1,001,000	12.7
Dug	985,000	12.5
Bored	407,000	5.2
Jetted	91,000	1.2
Could not be determined	847,000	10.7
Total	7,893,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Figure VII-5
Drilled Wells



Hydraulic-Percussion Drilled Well

casing
drill stem
ball check area
water course
sand, gravel & water return
drill bit
water discharge
water return
settling tank

Rotary Drilled Well

kelly
rotary table
mud pump
settling pit
storage pit
drill pipe
water table
drill stem
drilling fluid (mud)
rotary drill bit

Figure VII-6
Dug Well

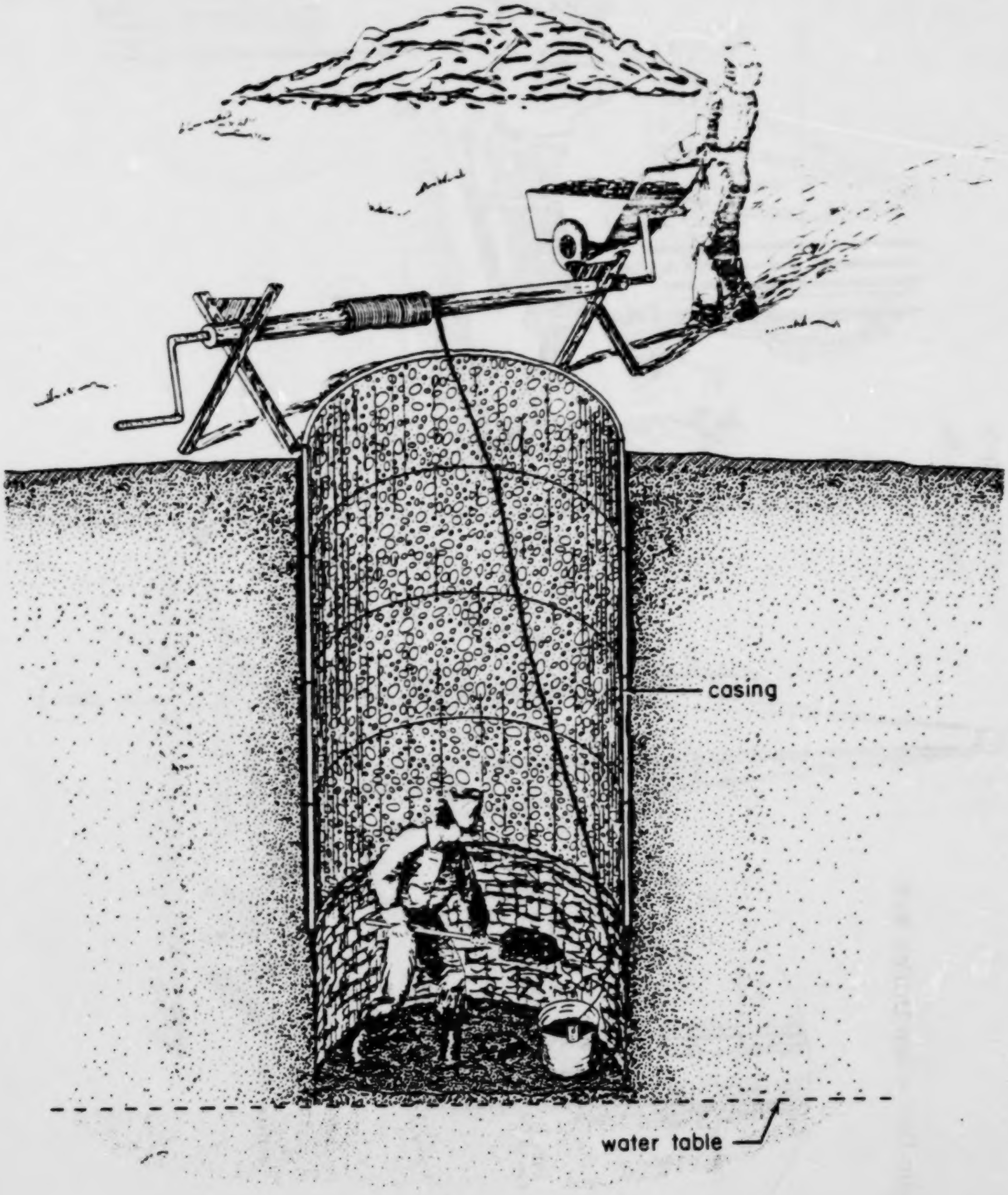

casing
water table

Figure VII-7
Driven Well

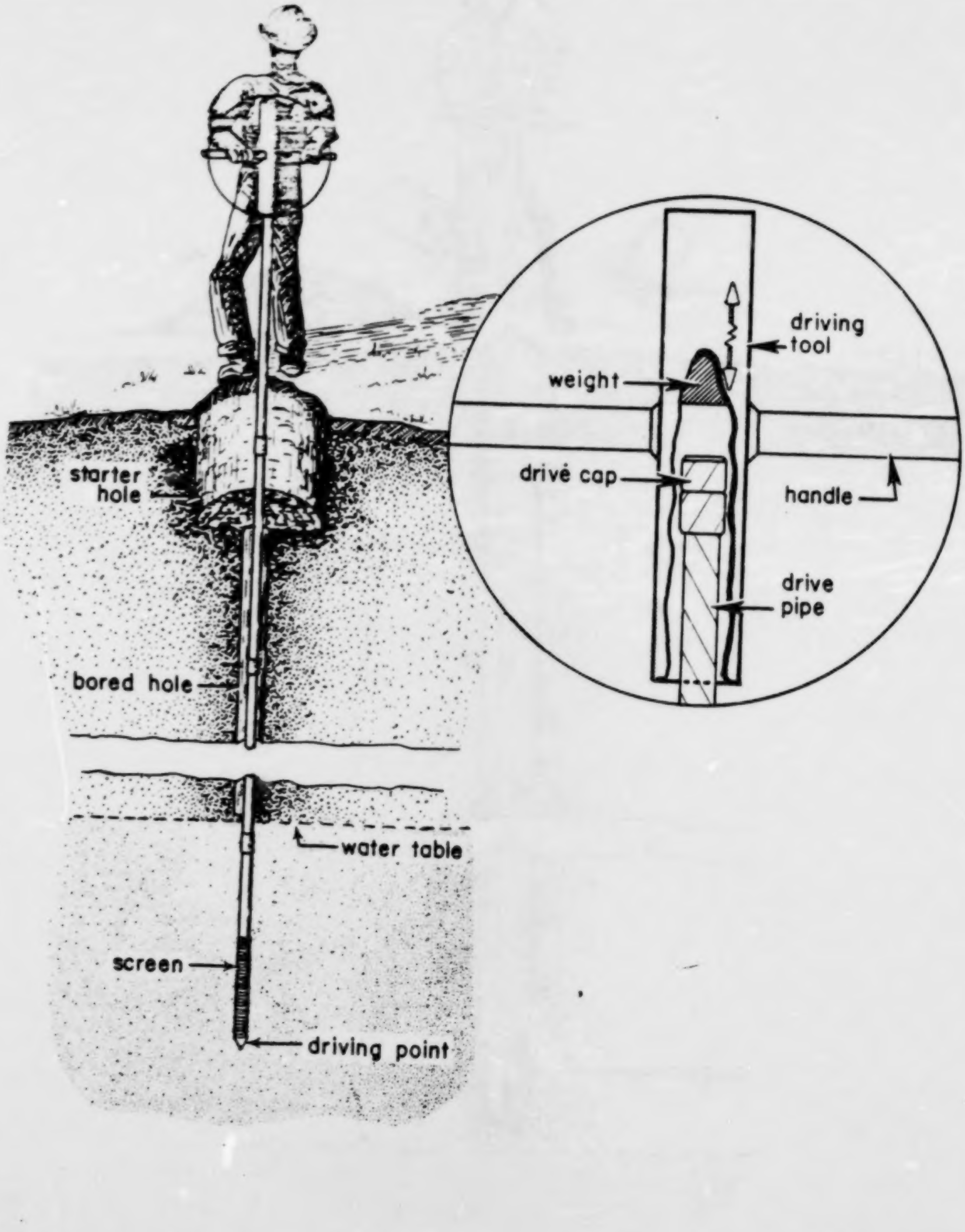

driving tool
weight
drive cap
handle
drive pipe
starter hole
bored hole
water table
screen
driving point

Figure VII-8

Bored Well

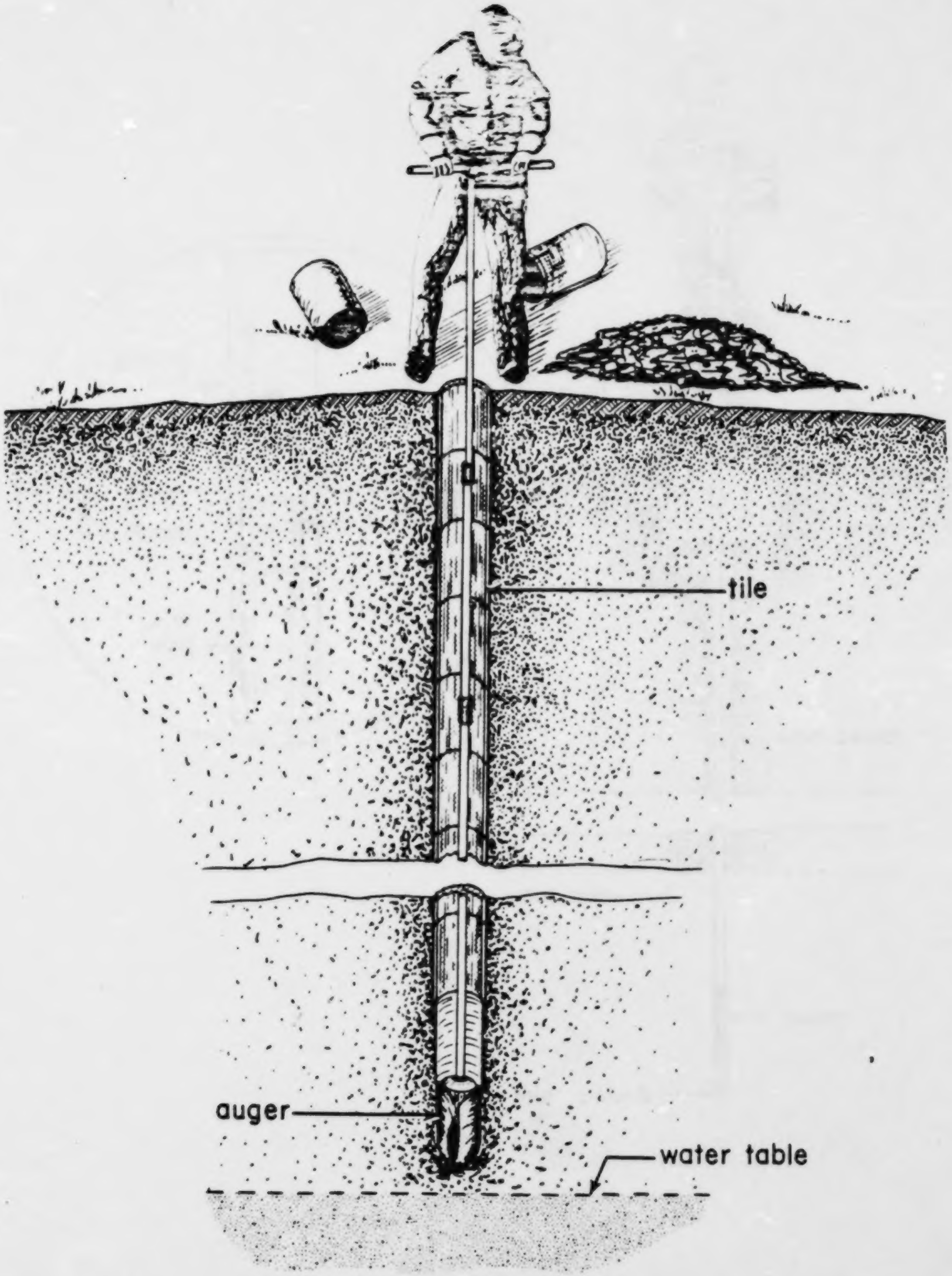
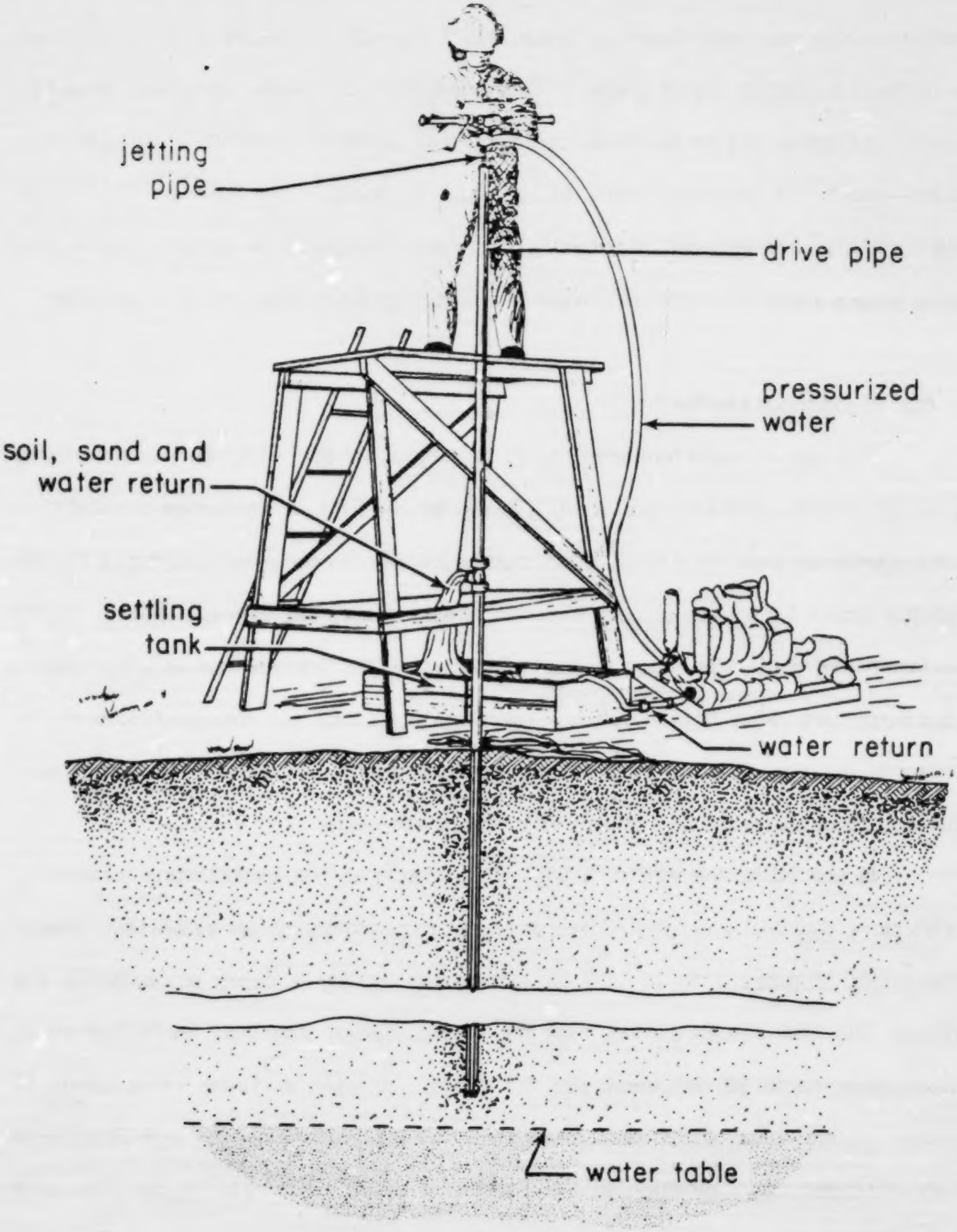

tile
auger
water table

Figure VII-9

Jetted Well


jetting pipe
drive pipe
pressurized water
soil, sand and water return
settling tank
water return
water table

The type of construction could not be determined for nearly 11 percent of individual wells.

The predominance of drilled wells indicated favorable conditions in regard to key aspects of water supplies. For example, as to water quality, bacterial contamination has been found to occur less frequently in drilled, driven, or jetted wells than in dug or bored wells.[3] This apparently favorable situation, however, should not cause one to overlook the fact that a sizable proportion of individual wells—nearly 18 percent—were either dug or bored. As already noted, the relationships between well construction characteristics, water supply quality, and other supply aspects will be investigated in detail in later chapters of this report.

— Age of individual wells

The age of wells has been linked to various aspects of systems, particularly to water quality. For example, a 1971 survey by the EPA in Tennessee showed that the majority of individual rural wells studied exceeded recommended Public Health Service limits for coliform bacteria. In that survey, the average age of highly contaminated wells was about twenty years, while the average age of uncontaminated wells was about fifteen years.[4] Investigators concluded that corrosion of the casing in older wells permitted contamination from the surface, or that workmanship or casing materials had improved in the newer wells.

In the NSA, the age of a well was defined as the approximate number of years since the well was constructed or since it received a major alteration. Major alterations included such actions as increasing the well's depth or replacing the casing. The NSA results showed that the median age of individual wells (for which information could be obtained) was 8.2 years. As seen in Table VII-4, about 16 percent of individual wells were more than twenty years old—the age associated with increased contamination in the Tennessee study. The relation between well

Table VII-4

Age of Individual Wells

Age (Number of Years Since Construction or Alteration)	Nation	
	Number of Systems	Percent of Systems
5 or less	2,683,000	34.1
6 - 10	1,453,000	18.4
11 - 15	906,000	11.5
16 - 20	588,000	7.5
21 - 50	1,109,000	14.0
More than 50	171,000	2.2
Could not be determined	984,000	12.4
Total	7,893,000	100.1

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

age, water quality, and other aspects of domestic supply will be explored in later chapters.

— Depth of individual wells

The depth of wells also has been associated with key aspects of water supplies. As to quality, the EPA has observed that "wells that extend only a short distance into shallow water tables are more likely to be contaminated than wells that penetrate more deeply."[5] Quantity, availability, and cost of water also have always had recognized links to the depth of wells—links which will be explored in detail in later chapters.

On the basis of the NSA findings, the median depth of individual wells for which information was available was 26.8 meters (87.9 feet) from ground level to bottom of shaft. As can be seen in Table VII-5, the majority of wells (52.4 percent) were 30 meters (98.4 feet) deep or less. Within that depth range, about five of every ten wells were 15 meters (49 feet) deep or less. As to deeper wells, slightly more than one-third of all wells were 31 meters (101.7 feet) through 152 meters (498.7 feet) deep. Less than 1 percent of all rural wells were in the 153 through 330 meter (502 through 1,082.7 feet) range.

— Casing diameter for individual wells

As the well shaft is sunk, a casing must be installed inside the bore hole to create a permanent well. For drilled wells, the casing generally is steel—frequently in the form of standard steel pipe. The purpose of the casing is to maintain the physical integrity of the well and to keep contaminants from seeping into the shaft and then down into the supply. The casing is not intended as a suction pipe for drawing up the water.[6] A separate pipe is installed for this purpose.

The diameter of the casing may be an important factor in well cost and in the capacity of the centrifugal pump which can be installed. Respondents in the

Table VII-5

Depth of Individual Wells

Depth in Meters	Approximate Depth in Feet	Nation Number of Systems	Nation Percent of Systems
3 or less	Less than 10	153,000	1.9
4 - 9	11 - 30	909,000	11.5
10-15	31-50	945,000	12.0
16-21	51-70	855,000	10.9
22-30	71-100	1,268,000	16.1
31-61	101-200	2,011,000	25.5
62-91	201-300	477,000	5.9
92-122	301-400	200,000	2.5
123-152	401-500	82,000	1.1
153-330	501-1,082	54,000	0.7
Could not be determined		938,000	11.9
Total		7,893,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

NSA were asked the diameter of their well casings if the wells were drilled, driven, bored, or jetted. There were a total of about 6.9 million individual wells in these classifications. For about 15 percent of these wells, information about the casing diameter could not be obtained. The NSA data indicated the prevalence of certain standard even-size casing. That is, the diameter of nearly 10 percent of individual well casings was 5.1 centimeters (two inches); the diameter of 2.5 percent was 7.6 centimeters (three inches); the diameter of 10.5 percent was 10.2 centimeters (four inches); the diameter of about 26 percent was 15.2 centimeters (six inches); and the diameter of 6.5 percent was 20.3 centimeters (eight inches). The diameters of the balance of the casings (about 29 percent) were fairly evenly distributed between the even-size diameters.

Although such even-size standardization could be anticipated, the findings also may have reflected approximations made by NSA respondents. That is, the respondents may have felt more comfortable reporting the diameters to the nearest inch rather than making finer estimates. There was no direct way to determine whether this effect occurred in the NSA, but some respondents clearly had difficulty in providing information. This is indicated by the fact that, as reported above, about 15 percent of rural households with the relevant types of wells could not produce the necessary data about casing diameter.

— Grouting in individual wells

Construction of the well may leave a space between a segment of the casing and the surrounding earthen bore hole. Polluted water from the surface can collect in the space and eventually seep down along the outside of the casing and into the aquifer which feeds the supply. The standard countermeasure is to fill the space with grout (usually cement) to keep out the water. However, the need for grouting depends on the type of well construction and on the ground conditions.

Any type of well may require grouting, but the procedure is most common for certain types of drilled wells (see Figure VII-10).

NSA respondents were questioned about the grouting status of drilled, driven, bored, or jetted wells. Responses were obtained which were relevant to 6.8 million individual wells in rural America—slightly less than the total of 6.9 million wells in these four construction classifications. About 39 percent of the 6.8 million wells (a total of 2.6 million) were not grouted; about 35 percent (a total of 2.4 million) were grouted. Grouting status for the other 26 percent of wells could not be determined.

— Wellhead sealing against pollutants

Arrangements for protecting rural wells from external contamination were checked when possible by direct inspection. NSA interviewers were specially trained by sanitary engineering experts to make the inspection. If the inspections could not be made, NSA respondents were asked questions about specific protective measures.

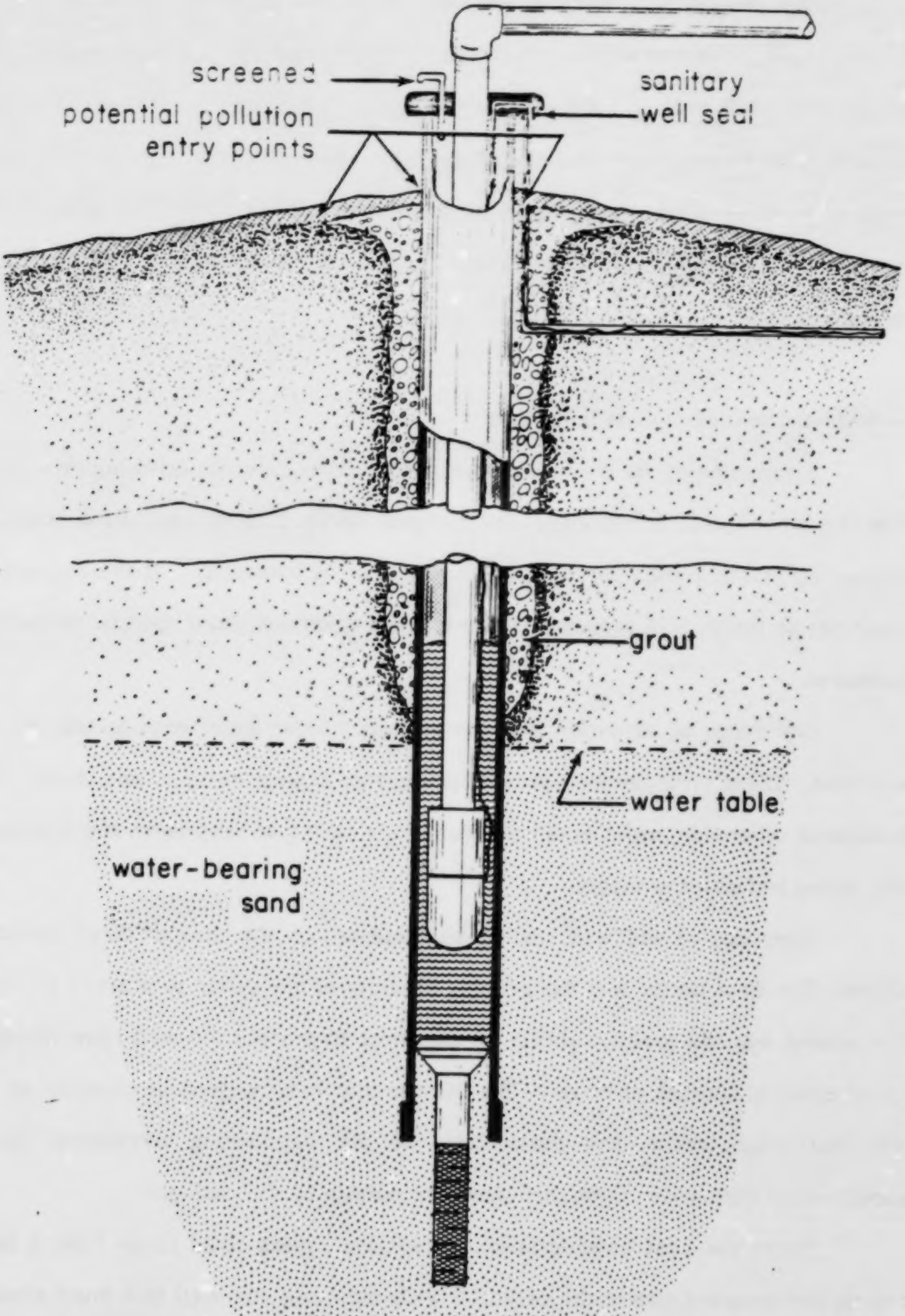
One focus of attention was the adequacy of arrangements to seal off the wellhead. These arrangements provide protection against entry of pollutants. The pollutants otherwise might enter the well shaft casing or seep down the outside of the casing and into the supply.

Adequacy of wellhead sealing was assessed on the basis of three considerations. The first factor was the general capacity of the cover to protect the well. The second was the specific ability of the cover to protect the well from runoff or other external sources of water. The third factor was the general capacity of the wellhead arrangement—and particularly of the surrounding terrain—to divert runoff which otherwise might seep down the outside of the casing.

As to the first consideration, acceptable covers could range from a large reinforced concrete slab in the case of a wide-diameter dug well to a much smaller

Figure VII-10

Pollution Countermeasures in Drilled Well


screened
potential pollution
entry points
sanitary
well seal
grout
water table
water-bearing
sand

tip-up metal cap in the case of a well with a pitless-adapter access pipe (discussed later). In any event, the cover was judged unacceptable if it had an opening wider than 1/16th inch, allowed pollutants or small animals to enter the well, or was associated with a pump which had to be primed more than once a month (priming could introduce pollutants). However, covers generally were judged on the basis of their overall appearance of sturdiness and repair rather than on the basis of their specific features.

As is evident from Table VII-6, well covers generally were acceptable. Slightly more than one-fifth of the covers were not acceptable, however. The cover condition could not be determined for a small percentage of wells.

The second consideration related to wellhead sealing was the ability of the well cover to keep runoff from entering the casing. The cover had to be watertight and not exposed to flooding in order to be classified as splashproof. For many drilled wells, splashproofing required the presence of a device called a sanitary seal. The seal had to block off the wellhead opening of the casing, yet accommodate pipes or other items which had to pass down into the casing. One type of seal, for example, consisted of two metal plates sandwiching a rubber gasket between them. Pipes passing into the well went through holes predrilled through the plates and gasket. Once the equipment was in position, the two plates could be tightened, forcing the rubber gasket to bulge out against the pipes and against the sides of the well casing. The gasket thus blocked off surface water which might otherwise seep into the casing.

NSA results showed that many well covers (74.7 percent) were splashproof (see Table VII-6). Nevertheless, 1.6 million rural wells had covers which were not splashproof.

Whereas the first and second considerations about wellhead sealing were related to the ability of the well cover to keep runoff from the inside of the casing, the third consideration was more (but not exclusively) related to the ability of the

Table VII-6

Adequacy of Wellhead Sealing and Source Protection

Characteristic	Nation Number of Systems	Percent of Systems
Cover (general acceptability)		
Acceptable	5,808,000	73.6
Unacceptable	1,752,000	22.2
Could not be determined	334,000	4.2
Total	7,893,000	100.0
Cover (splashproof or not)		
Splashproof	5,896,000	74.7
Not splashproof	1,562,000	19.8
Could not be determined	436,000	5.5
Total	7,893,000	100.0
Source protection		
Adequately protected	5,930,000	75.1
Not adequately protected	1,598,000	20.2
Could not be determined	365,000	4.6
Total	7,893,000	99.9
Combined evaluation		
Acceptable on all three factors	4,925,000	62.4
Unacceptable on one factor	746,000	9.5
Unacceptable on two factors	679,000	8.6
Unacceptable on all three factors	870,000	11.0
Could not be determined	673,000	8.5
Total	7,893,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

wellhead arrangement to keep runoff from the outside of the casing. Two major questions were investigated. The first was whether the well construction, soil landscaping around the wellhead, and general terrain features could keep surface water from entering the space between the well casing and the soil around it (from there, the water could seep into the well supply and contaminate it). The second question was whether the wellhead was secure from surface drainage: even if the well construction were otherwise adequate, the well was not regarded as secure if drainage reached it.

If water could seep down the outside of the casing, or if surface water could drain directly to the wellhead, the water source for the well was classified as not adequately protected, even if the construction features included other countermeasures against flooding. As seen in Table VII-6, the sources of about 20 percent of individual wells were classified as not adequately protected, and the sources of about 75 percent were classified as adequately protected.

The three factors used in the NSA to judge the adequacy of wellhead sealing and source protection were very closely related, and the results appeared very similar—on each factor, about three-quarters of all individual wells were rated acceptable and about one-fifth were rated unacceptable. Yet comparisons of the data showed that interviewers generally had made careful distinctions and had evaluated each condition separately, as directed by NSA procedures.

For example, when the three factors were tabulated together rather than independently (see "Combined evaluation" in Table VII-6), 9.5 percent of all individual-system wells were rated unacceptable with regard to one factor, 8.6 percent as unacceptable on two factors, and 11.0 percent as unacceptable on all three factors. The low level of congruence among the three sets of results (shown by statistical tests not presented here) indicated that a system's being rated unacceptable on one factor did not necessarily mean that it would be rated unacceptable on other factors. If interviewers had not been making careful distinctions, a much larger proportion of the wells would have been rated unacceptable on two, or even all three, factors. Thus, in those 11.0 percent of individual wells rated as unacceptable on all three factors, the sanitary provisions tended to be so poor that the wells were rated as inadequately protected in regard to all three conditions, even though each condition was evaluated separately.

Moreover, although the separate evaluations in Table VII-6 would seem to indicate that nearly 75 percent of individual wells were acceptable with respect to each of the three factors, the combined evaluation showed otherwise. That is, the combined evaluation revealed that only 62.4 percent of individual wells, not 75 percent, were acceptable on all three factors. Likewise, a higher proportion than indicated by the separate evaluations—29.1 percent—were unacceptable on at least one factor. By the same token, fewer wells were unacceptable with respect to all three conditions.

— Distance to potential pollution sources

In addition to the considerations about wellhead sealing, the proximity of various potential pollution sources was investigated. This was done since well protection included measures to keep pollutants from entering the well in the first place. One obvious measure was to position potential pollution sources such as cesspools as far away from the well as possible.

The distance between the center of the wellhead and the possible sources of contamination was measured in the NSA. The distance itself was only one factor in determining the protection afforded the well, but that factor was the only one which could be determined reliably in the NSA. Other factors which could not be studied included the composition of the pollution source and the geology of the area between the source and the well.

The significance of the measured distances could be estimated only in a very general way. According to the EPA, "because many factors affect the determination of 'safe' distances between groundwater supplies and sources of pollution, it is impractical to set fixed distances."[7] The agency suggests that a distance of 15.24 meters (50 feet) is the minimum which should be used to separate a well from any pollution source. If the soil has poor filtering properties, or if the pollution source is particularly dangerous (a hazardous waste, for example), the distance should be considerably greater. If the well itself is poorly constructed, there is no safe distance, according to the EPA. In the analysis which follows, then, the actual reference used is sixteen meters (approximately 50 feet). The relationship between the distance and the quality of the well water is explored in Chapter X.

Whenever possible, NSA interviewers measured the distances themselves with the aid of an optical ranging device. If they could not measure, or estimate, the distance, they requested the information from household respondents. It is important to realize that, in reviewing the results in Table VII-7, measurements were recorded for only a limited number of possible pollution sources. Measurements usually were possible in the case of sewage disposal systems, but for other sources they were only infrequently available—some sources are more evident than others. (When measurements were not taken, there may have been no potential pollution source of that type present, or a source may have been overlooked. Also, in some instances, measurements or estimates may have been impossible, or the respondents may have been unable to provide key information. Relevant proportions are given in the first column of Table VII-7.)

It appears from Table VII-7 that potential pollution sources generally presented little threat to individual rural well systems. Considering only those well systems for which measurements were obtained, the median distance between wellhead and potential pollution source was more than sixteen meters for all sources. For the most part, less than 10 percent of individual wells were located

Table VII-7

Distance Between Individual Wells and Potentia Pollution Sources

	Nation		
Type of Potential Pollution Source	Percent of Wells Where No Potential Pollution Source Was Determined*	Percent of Wells Within 16 m of Potential Pollution Source*	Median Distance from Potential Pollution Source**
Sewage disposal system	16.7	20.2	25.8 m (6,574,000)
Oil or gasoline tank	80.3	8.9	20.0 m (1,554,000)
Animal waste	79.8	8.0	23.0 m (1,598,000)
Agricultural fertilizer or runoff	78.7	7.9	29.7 m (1,682,000)
Surface water contamination (such as pond, lake, or river which might flood into well)	85.2	4.8	31.3 m (1,171,000)
Highway salt	95.8	1.8	21.0 m (329,000)
Industrial waste	98.8	0.2	180.2 m (97,000)
Other contamination	97.7	1.0	19.8 m (182,000)

*Base: All individual wells (7,893,000).

**Median distances were calculated from measurements at wells where potential pollution sources of each type were noted; bases given in parentheses.

within sixteen meters of various potential pollution sources. Nonetheless, 26.2 percent of individual wells were within sixteen meters of sewage disposal systems.

— Access to well equipment (pitless adapter, buried seal)

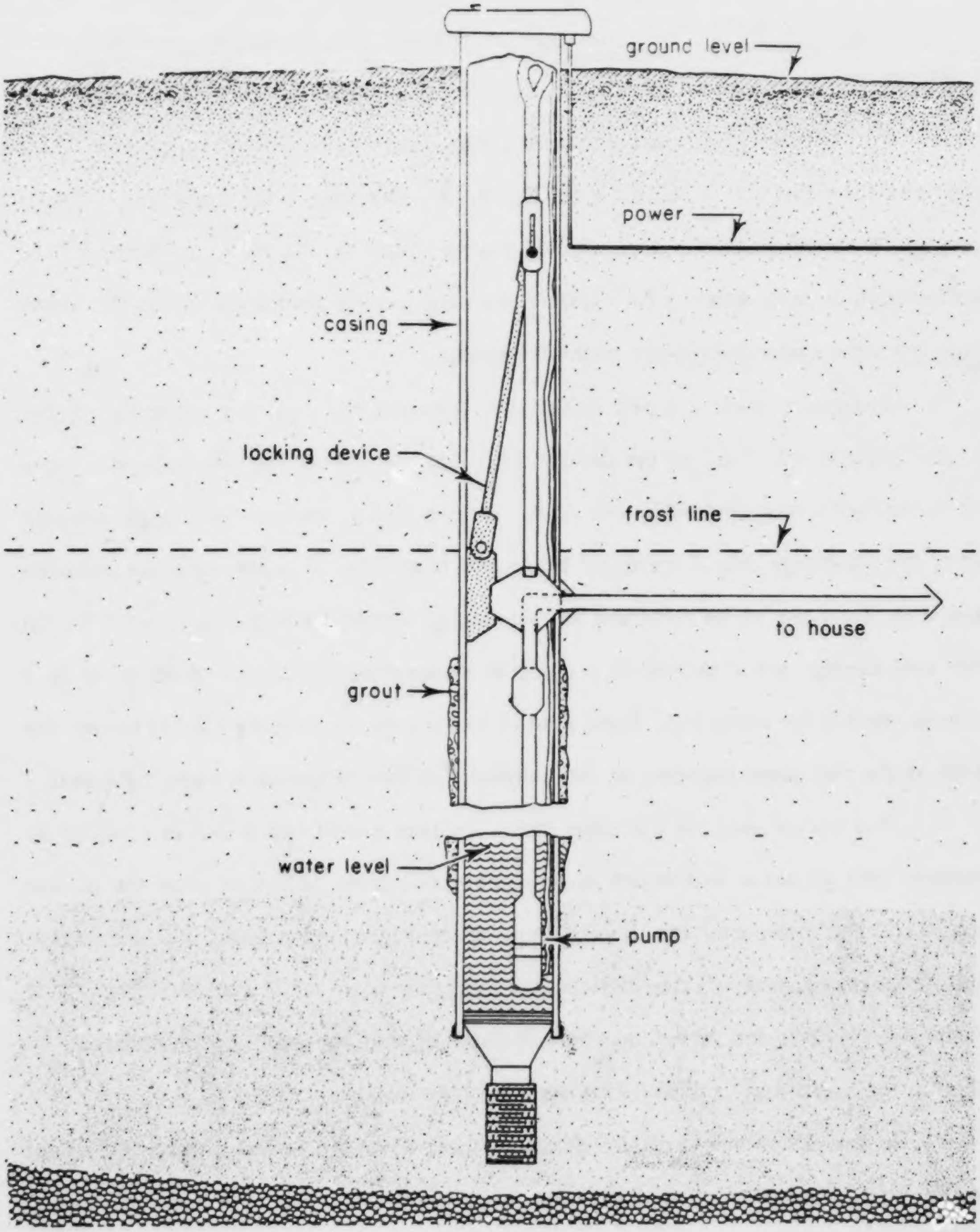
All wells should be accessible at the top for inspection, servicing, and testing.[8] In wells which terminate above ground, one option is installation of a pitless unit or pitless adapter, a special fitting (see Figure VII-11) which eliminates the need for a pit, and is named accordingly. An alternative for wells which do not terminate above ground and viewed as unacceptable by the EPA[9] is the so-called buried seal, an arrangement for capping the well underground and leading the water pipe from the underground cap to the household.

Engineers draw a sharp distinction between the sanitary integrity of the pitless adapter and that of the buried seal, and the use of the two different types of connections was studied in the NSA. In the pitless adapter or pitless adapter unit, the discharge line is installed below the frost line. It is permanently installed and does not have to be removed for servicing. Other fittings are located within the well casing, are attached to a pump or pump intake, and can be removed by a lift-out device for servicing. Some kind of locking device (Figure VII-11) forces the ends of the two pipes together at the adapter junction to create a watertight seal.

The buried seal, on the other hand, utilizes a well cap which is covered by several feet of earth and which is less protected from pollution than the pitless adapter. Furthermore, the buried seal discourages inspection and preventive maintenance because of the difficulty of digging down to it for servicing.[10] If excavation is done for servicing, there is the risk that the seal will be damaged by digging tools and that pollution may seep into the casing.

In the NSA survey, pitless adapters were installed in 2.3 million individual wells—or 28.9 percent of all individual wells in rural America. Buried seals were installed in fewer systems: they were in a total of 1.5 million wells, or 19.6 percent

Figure VII-11
Pitless Adapter


ground level
power
casing
locking device
frost line
to house
grout
water level
pump

of all individual wells in the rural US (see Table VII-21 in the "regional variation" section, below).

At nearly 3 percent of rural households with individual wells, the residents did not know whether there was a pitless adapter or buried seal, and the question could not be resolved by inspection of the wells.

Individual springs

Although wells usually provided the groundwater for individual systems, springs occasionally were used. Of the 8,168,000 individual systems that used groundwater, only 275,000 had springs.

Springs (see illustration in Chapter IV) were thought to be particularly susceptible to contamination—a concern borne out by previous studies.[11] In the NSA, certain aspects of pollution intrusion protection such as those studied for wells, above, were studied for springs also. The aspects studied were the adequacy of cover protection for the spring reservoir, the adequacy of source maintenance, and the proximity to specific pollution sources.

— Intrusion protection for individual springs

If a spring has some type of underground interception or storage reservoir, the reservoir should have an adequately covered access port. The cover should keep out pollutants and animals.

NSA results showed that two of every three individual springs had either an unacceptable cover or no cover at all. About 31 percent of springs had acceptable covers; the situation could not be determined for about 2 percent of springs.

In addition to having adequate cover, a spring should be protected in other ways as well. For example, surface water should not drain directly into the spring. Also, the spring should be fenced in to keep away animals and unwary human beings. In the NSA, these conditions were categorized as those necessary for source protection. The NSA results showed that about 56 percent of springs were not adequately protected. Source protection was adequate for 42 percent of springs, and the condition could not be assessed for about 2 percent of springs.

— Distance to potential pollution sources

Since spring supplies are at or near ground level, nearby sources of pollution are especially risky. This is particularly true since, as just reported, the majority of individual springs in rural America do not have adequate covers or source protection.

Distances between rural individual springs and various potential pollution sources are given in Table VII-8. In analyzing the data in the table, it is important to note that, as with wells, measurements were not made for many springs (see first column). As was true for wells, there may have been no pollution sources, or the sources may not have been recognized. The median distance between springs and each type of possible pollution source is given in the third column of the table. In interpreting the data, it is necessary to realize that the distances themselves are of limited use in gauging pollution potential. Although a distance of 15.24 meters is regarded as the minimum which should exist between wells and pollution sources, no such rule-of-thumb minimum distance has been established for springs. Contamination from surface sources depends, among other things, on whether the sources are located on higher land (so that drainage flows down to the spring) and whether there is a surface water diversion ditch (so that drainage will be directed away from the spring). These conditions were not systematically assessed in the NSA. Thus, in Table VII-8, the reference distance used is an arbitrary one—30 meters, or about twice the recommended minimum distance between well and pollution source.

For those springs where measurements were performed, the median distances between the springs and some major potential pollution sources (sewage

Table VII-8

Distance Between Individual Springs and Potential Pollution Sources

Type of Potential Pollution Source	Nation Percent of Springs Where No Potential Pollution Source Was Determined*	Percent of Springs Within 30 m of Potential Pollution Source*	Median Distance from Potential Pollution Source**
Surface water contamination (such as pond, lake, or river which might flood into spring)	58.7	34.3	1.0 m (113,000)
Sewage disposal system	34.7	13.9	53.1 m (179,000)
Animal waste	70.4	10.9	38.3 m (81,000)
Oil or gasoline tank	84.1	3.6	57.5 m (44,000)
Agricultural fertilizer or runoff	88.0	2.2	79.6 m (33,000)
Highway salt	98.2	1.8	***
Industrial waste	98.7	0.0	***
Other contamination	98.2	1.8	***

*Base: All individual springs (275,000).

**Median distances were calculated from measurements at springs where potential pollution sources of each type were noted; bases given in parentheses.

***Insufficient data for calculation of median: 4,000 individual springs were 808 meters from sources of industrial waste; 5,000 were six meters from highway salt; and 5,000 were six meters from other contamination sources.

disposal systems, fuel tanks, animal waste, and fertilizer runoff) were greater than 30 meters. This finding indicated a certain degree of security for many springs. On the other hand, more than 10 percent of all individual springs were less than 30 meters from either sewage disposal systems or animal waste (see middle column of data). Also, as reported in the footnotes, for the small number of households where measurements were made, springs were six meters away from highway salt and from other possible contamination sources.

The most striking finding was that, when measurements were made to sources of surface water contamination, the contamination source tended to be adjacent to the spring (the median distance was one meter). The discovery that nearly three of every ten springs were so close to surface water contamination was consistent with typical spring configurations and with other NSA data. That is, spring systems usually had a pool of water created by the spring itself. This pool could become contaminated in a number of ways and lead to pollution of the domestic water supply. NSA findings (see above) showed that source protection was inadequate for the majority of springs—meaning that surface drainage or other contaminants could enter the spring. Adjacent surface water contamination thus implied a likelihood that the spring pool itself became a source of contamination for the supply.

In summary, the majority of individual rural springs used for major domestic water supplies were inadequately protected from contamination. Specifically, reservoirs often had inadequate covers, the source tended to be inadequately shielded from pollution, and the spring pool itself tended to be subject to contamination which could be passed on to the domestic supply.

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Individual cisterns

The second most prevalent source of water was precipitation, supplying 133,000 individual cistern systems (Table VII-1). These systems, as all others reported in this chapter, provided the major domestic household supply.

Previous studies indicated that cisterns in America had various technical inadequacies. One study of individual cistern systems in the Southeast in the early 1970s showed that "cisterns were generally poorly constructed and maintained without any means either for filtering the incoming water or for disinfecting it prior to use. The cisterns . . . seldom had any provision for draining and cleaning. Indeed, many lacked even minimal protection to exclude insects, birds, and rodents."[12]

Four structural features related to these considerations were studied in the NSA (see Figure VII-12). The first was a special manual or automatic device to divert initial water flow after a rainstorm to protect the supply from leaves and other debris which had accumulated in the runoff area leading to the cistern. The second feature was a drain at the bottom of the cistern reservoir to facilitate periodic emptying and cleaning. The third feature was the location of the catchment area—the surface from which rainwater was collected for the cistern. Ground level catchment areas (leading to subsurface reservoirs) could be adequate, but elevated catchment areas generally were considered less prone to contamination. The fourth feature was a cover which protects against pollution—the same feature studied in wells and springs. Other aspects of cistern systems studied in the NSA (also studied for wells and springs) were the protection of the source from pollution sources and the distance of the cistern from contamination sources.

— Structural characteristics of cisterns

Many individual cistern systems in rural America appeared to be pollution prone (Table VII-9). Nearly six of ten systems had no first-water diverter, and

Figure VII-12

Cistern Supply

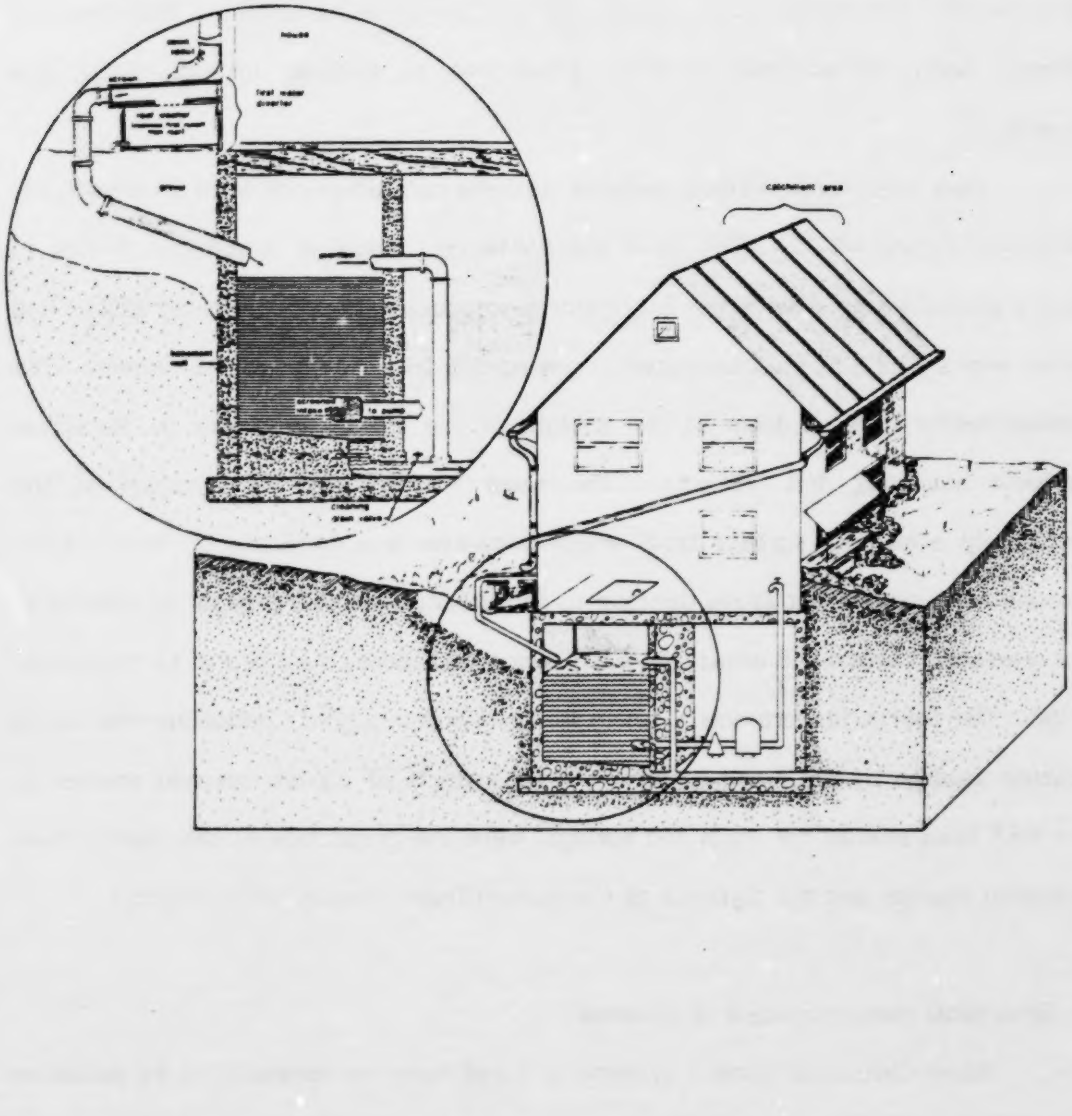
house
screen
first water diverter
overflow
screened intake
to pump
cleaning drain valve
catchment area

Table VII-9

Structural Characteristics of Individual Cisterns

Characteristic	Nation Number of Systems	Percent of Systems
First-water diverter		
No diverter	78,000	58.7
Manual diverter	49,000	37.0
Automatic diverter	6,000	4.3
Total	133,000	100.0
Cleaning drain		
No drain	101,000	76.0
Drain present	22,000	16.1
Could not be determined	10,000	7.9
Total	133,000	100.0
Location of catchment area		
On the roof	133,000	100.0
Total	133,000	100.0
Cover (general acceptability)		
Acceptable	83,000	62.4
Unacceptable	41,000	30.4
Could not be determined	10,000	7.1
Total	133,000	99.9

those systems which did have diverters generally had manual ones, some of which may have been improvised arrangements requiring attention during each rain. Cleaning drains were not installed in 76 percent of the systems. Covers were judged unacceptable for excluding contamination at 30.4 percent of the systems.

On the positive side, all of the systems had rooftop catchment areas rather than the more easily contaminated surface catchment areas. This did not mean, however, that ground level catchment systems did not exist in rural America. Such systems may have been too infrequent to encounter in the NSA survey.

— Protection from pollution sources

As to other pollution-related considerations for cistern systems, the systems generally were adequate, or else the situation could not be determined. Conditions clearly were poor at some systems, however. Most systems (84.3 percent) were judged adequately maintained in terms of protection from external pollution sources such as runoff or animals (source protection). Source protection was inadequate at only 4.3 percent of all systems; the situation could not be determined at 11.4 percent.

The EPA advises that cisterns should be at least 15.24 meters (50 feet) from sewage disposal sources,[13] and although 4.3 percent of all cistern systems were at least this far away, 21.7 percent (a total of 29,000) were closer; the situation could not be determined for 74 percent of the systems (a total of 99,000). (As with wells and springs, when measurements were not taken, there may have been no pollution source present, or potential sources may not have been recognized.)

No measurements were made between cisterns and oil or gasoline tanks. The same was true for most cisterns in regard to distance from animal waste, but 6,000 cisterns were judged to be immediately adjacent to this potential pollution source. A similar pattern existed for cisterns in regard to distance from surface water contamination: no measurements were made for 91.4 percent of cistern systems, but 11,000 systems (8.6 percent) were in the immediate vicinity of surface water contamination.

No measurements were made between cisterns and industrial waste pollution sources. Likewise, measurements were taken between cisterns and sources of fertilizer pollution for only 6,000 cisterns (4.3 percent of all cisterns): those systems were 120 meters away from the source. A total of 6,000 cisterns were next to highway salt pollution; no other measurements were made. A total of 6,000 cisterns were nine meters from a source of other contamination; again, no other measurements were made.

Individual surface water systems

The least prevalent water source for individual systems was surface water. Lakes, streams, ponds and the like—whether or not spring-fed—were classified as surface water. These sources supplied only 93,000 individual systems in rural America.

Sanitary protection of surface water is very difficult, and the EPA advises that "a pond or lake should be considered as a source of water supply only after groundwater sources and controlled catchment systems (cisterns) are found to be inadequate or unacceptable."[14]

If surface water is used, a number of precautions are advisable, ranging from care of the source to processing and treatment of the water. In the NSA, only a relatively few conditions were studied. One was the standard situation regarding an acceptable cover for intrusion protection. A cover over a lake or pond obviously was impossible, but consideration was given to satisfactory substitute measures, such as barriers around the source or protection for the intake system. It was decided that there were no realistic substitute measures, and all

93,000 surface water sources thus were judged to have unacceptable intrusion protection in this regard.

One condition which could be evaluated was the adequacy of source protection—the same condition evaluated for systems supplied by groundwater or precipitation. Surface water sources were regarded as adequately protected against pollution if they were fenced, surrounded by a well-kept grassy area, and kept free of weeds and floating debris. About 41 percent of all individual rural systems supplied by surface water were evaluated as having adequate source protection; 59 percent were evaluated as not having adequate protection.

Since intrusion protection for surface water sources is so difficult, the proximity of pollution sources is an urgent consideration. A minimum acceptable distance would depend on so many factors that no attempt is made to compare NSA data to a standard reference distance. Instead, the findings are simply summarized for each type of pollution source studied. The sources reported on are the same as those discussed for systems using other sources.

In at least two instances, nearness to potential pollution sources underscored the potential sanitary problems in surface water systems (Table VII-10). One common potential pollution source was animal waste, which was near a large proportion of surface water systems. A second common source of possible pollution was the system source itself, which, of course, was recorded as being zero meters from the source.

General system considerations for all individual systems

The discussion of individual systems in this chapter began with general categorical considerations—the source, ownership, and length of service for all individual systems. Then came the detailed examination of water-quality related engineering features, which generally were external to the household, and which

Table VII-10

Distance Between Individual Surface Water Systems and Potential Pollution Sources

Type of Potential Pollution Source	Nation: Percent of Surface Water Systems Where No Potential Pollution Source Was Determined*	Nation: Median Distance from Potential Pollution Source**
Sewage disposal system	48.3	25.8 m (48,000)
Oil or gasoline tank	74.9	19.0 m (23,000)
Animal waste	40.4	7.8 m (55,000)
Surface water contamination (source itself)	48.1	0.0 m (48,000)
Industrial waste	100.0	-
Agricultural fertilizer or runoff	69.8	108.4 m (28,000)
Highway salt	100.0	-
Other contamination	85.3	99.2 m (14,000)

*Base: All individual surface water systems (93,000).

**Median distances were calculated from measurements at individual surface water systems where potential pollution sources of each type were noted; bases given in parentheses.

were grouped according to different types of systems. Here the focus shifts back to certain general considerations relevant to all individual systems in rural America. In the presentation which follows, the supply is traced from the source to the household in an investigation of overall aspects of individual supplies ranging from methods for bringing water into the house to the history of laboratory testing of water quality. The preceding material on external engineering features provides a detailed background for this investigation.

Methods for bringing water into the household

The method for transporting water from the source to the household reflects a number of aspects of the individual system. An efficient system with a well supply, for example, would be likely to have a pump and associated piping. At the other extreme, an undeveloped surface source might have no mechanized transport system, forcing the user to carry water home in a bucket.

The NSA results showed that in 91.4 percent of all individual systems (regardless of source or type of supply), water was piped to the household under propulsive power of an electric pump. Only 0.8 percent of the supplies had hand pumps. Natural pressure provided the motive power in about 2 percent of systems (gravity flow pressure in 1.6 percent, and artesian pressure in 0.3 percent).

In 5.5 percent of all individual supplies, neither pump-generated nor naturally generated pressure was used. In those systems, water was either transported in bulk to the household or else carried there by hand.

The water was hand-carried in 342,000 systems (3.9 percent of all individual systems) and carried in bulk by truck or other conveyance in 136,000 systems (1.6 percent of all individual systems). To put this into perspective, it is important to remember that the systems being considered here are for the major household supply. Hand carrying, or even trucking, all water for the major supply could entail considerable hardship, a subject considered in Chapter IV.

The foregoing transport methods were utilized in more than 99 percent of individual systems. Other methods, or unknown methods, were utilized in less than 1 percent of systems.

Water distribution and treatment devices in individual systems

As water is moved from the source to the household, it often passes through a number of devices to propel, store, pressurize, or treat it. The devices are designed to affect the supply's quality, quantity, availability, and general characteristics, as studied in Chapter V.

The profile of devices for all individual systems (regardless of source or type of supply) is presented in Table VII-11. The devices are listed according to their approximate relative position in the sequence of equipment from the source to the household. As to purposes for the equipment, the pump and pressure tank work in conjunction to maintain supply pressure. Specifically, the pump (if it is a power versus a hand pump) forces source water into the pressure tank, where the water compresses air in the tank. The compressed air then provides the pressure necessary to force the water through household pipes; the pump is in operation only so long as needed to restore adequate pressure in the pressure tank.

The storage tank, which has a larger capacity than the pressure tank, is a ground level or elevated water reservoir which compensates for system water yield which is too low to meet peak household demand for water. The settling tank is an element in turbidity treatment systems commonly used for pond or lake water. The activated carbon filter counteracts offensive tastes and odors. A chlorinator adds disinfectant to the water supply. A phosphate feeder is installed before the pressure tank to counteract excessive iron content in the water supply. An oxidation filter is another type of iron-removal device. Water softeners counteract the effects of minerals, primarily calcium and magnesium compounds, which cause

Table VII-11

Water Distribution and Treatment Devices in Individual Systems

Device	Nation Number of Systems*	 Percent of Systems**
Pump	8,107,000	92.5
Pressure tank	7,817,000	89.2
Storage tank	683,000	7.8
Settling tank	28,000	0.3
Activated carbon or anthracite filter	92,000	1.0
Chlorinator	74,000	0.8
Phosphate feeder	33,000	0.4
Oxidation filter	102,000	1.2
Softener	1,544,000	17.6
Miscellaneous filters	291,000	3.3
Other devices	117,000	1.3

*Table reports systems having at least one device; some systems may have had more than one.

**Base: All individual systems in rural US (8,765,000).

hardness (see Chapter V). Miscellaneous filters can be installed at a number of places in the system.

It is apparent in Table VII-11 that the two devices found most frequently in individual supplies were the water pump and the pressure tank. As explained in the earlier discussion on methods for bringing water into the house, nearly all of the pumps in individual systems were electrically powered rather than hand-powered. The power pumps required pressure tanks for maximum efficiency, and it is clear from Table VII-11 that most individual systems with a pump probably also had a pressure tank. In contrast, only a small proportion of systems had storage tanks.

Among the various devices to treat water, only the water softener was used in more than a small percentage of systems. Particularly of note was the extremely infrequent use of the chlorinator. The consequences of this situation for water quality are examined in Chapter V, but it is worth noting here that chlorination has been viewed as advisable for many individual systems, and as essential for cistern systems. Individual cistern systems alone outnumbered chlorinators by nearly two-to-one (see previous discussion on cisterns), so they clearly were inadequately equipped by conventional standards. It is possible, of course, that chlorine or other disinfectants were added directly to the supply of some individual systems rather than being injected from a chlorinator, but this possibility was not studied in the NSA.

As to other aspects of the NSA findings, the data in Table VII-11 are for systems having at least one of the relevant devices. In a small proportion of systems, more than one device of a particular kind was reported. For example, about 1 percent of all individual systems had more than one pump—a possibility, for instance, in systems with secondary pumps for maintaining system pressure or for directing water to nonhousehold uses. A small percentage of systems also had more than one pressure tank, storage tank, water softener, activated carbon filter, or miscellaneous filter.

Finally, an important aspect of the adequacy of pumps, pressure tanks, and storage tanks is the capacity of those devices. In the NSA, the capacity of the devices was regarded as being a factor in determining the quantity of water used in the system. As such, the capacity was examined in detail in Chapter V.

Free advice or assistance for individual systems

Little information exists on a national scale about the availability of free advice and help for individual systems. Such assistance could have a bearing on the status of individual systems, and the situation was explored in the NSA. As seen in Table VII-12, some type of free assistance was obtained for 22 percent of all individual systems. The most frequent type of assistance was free chemical or biological testing of the supply. Other types of assistance, such as help in locating a supply source or in building the system, were rare.

Also of interest was the source of the free advice or assistance. The presentation in Table VII-13 shows that assistance or advice was obtained most often from local or state agencies or health departments, or from individuals or water softening companies. Assistance was rarely obtained from federal sources. Stores, contractors, and local plumbing companies were infrequent sources of free assistance or advice.

Individual system water test history

When performed regularly, standard testing procedures provide an indicator of water's suitability for human consumption and use. Particularly at the household level, where testing seldom is done routinely, a chemical or biological assay may produce important information about the system supplying the water and suggest how it should be improved.

To obtain data on water testing at the household, a series of questions was asked of all NSA respondents. The questions included inquiries about whether or

Table VII-12

Individual Systems Receiving Free Advice or Assistance

	Nation	
Type of Advice or Assistance	Number of Systems	Percent of Systems
Free chemical or biological test of water	1,563,000	17.8
Help locating source of supply	218,000	2.5
Information about building the system	114,000	1.3
Information about altering the system	109,000	1.2
Advice about finding site for the system	54,000	0.6
Other advice or assistance	38,000	0.4
Any type*	1,928,000	22.0
Total Systems	8,765,000	

*Refers to number of systems receiving at least one type of advice or assistance. Since more than one type of aid could be received, number is smaller than obtained by adding rest of column numbers.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-13

Source of Free Assistance or Advice Received by Individual Systems

Source	Nation Number of Systems	Percent of Systems
Local government agency	519,000	26.9
An individual	380,000	19.7
Water softening company	266,000	13.8
State health department	237,000	12.3
Large chain store	53,000	2.7
Local building contractor	38,000	2.0
Cooperative extension	30,000	1.6
Local plumbing company	14,000	0.7
US Environmental Protection Agency	13,000	0.7
Farmers Home Administration	6,000	0.3
State environmental department	5,000	0.3
Miscellaneous	208,000	10.8
Could not be determined	159,000	8.2
Total	1,928,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

not the water had been tested in the past, the frequency of testing, the approximate date and the reason for the most recent test, the party that requested it, the type of test, and the test results. Each question was designed to elicit information only on tests done on water specimens collected at the individual's household and examined in laboratories by qualified personnel. This definition of a test eliminated from consideration certain less recognized tests as well as partial tests of water quality. The principal objective of collecting information about past water quality tests was to supplement the more current information about water quality compiled in the NSA itself (see Chapter V).

The responses to the questions on water testing indicated that approximately 37 percent of the households with individual systems had had their water tested professionally at least once. In slightly more than five million, or 58 percent of the households, tests had not been done, while in the remaining 5 percent it was not known if tests had been performed.

The frequency of testing in households served by individual systems varied considerably. In about 0.6 percent of the households in which testing had been done, the water had been tested 70 times or more, while in 83.5 percent, the water had been tested only once or twice. Although testing could conceivably be accomplished throughout the year, more tests were done in June, July, and August than in any other three-month period. In contrast, the least popular months for testing were December, January, and February. About 49 percent of those who said testing had been done could not specify the month when the last test was made. This, in combination with the data on testing incidence, suggested that for individual systems, testing was an intermittent rather than a regular activity. Furthermore, the wide range in the number of tests in households suggested notable differences in the condition of water supplies or in regulatory requirements.

In historical terms, the majority of the tests for these households were performed between 1970 and 1979. This trend is portrayed in Table VII-14, which

Table VII-14

Year of Most Recent Water Quality Test Among Individual Systems

	Nation	
Year of Most Recent Test	Number of Systems	Percent of Systems
Before 1930	5,770	0.2
1930-39	5,270	0.2
1940-49	58,600	1.8
1950-59	213,000	6.5
1960-69	539,000	16.5
1970-79	2,233,000	68.6
Unknown	203,000	6.2
Total	3,257,000	100.0

presents data on the frequency of testing for each ten-year interval after 1930. As can also be observed from the table, about 85 percent of the tests were conducted after 1960, and only 8.7 percent were done before that year. The largest proportionate increase in testing over any two consecutive decades occurred during the twenty-year period after 1930: about ten times as many tests were done in the 1940s as in the 1930s. While other explanations are plausible, it seems that this increase probably was attributable to the sudden proliferation of mandatory testing regulations.

The reasons for testing the water differed substantially among households. However, while eight distinct reasons were given for performing quality tests, the two mentioned most often accounted for slightly more than 75 percent of all reasons. These two predominant reasons for the testing were (1) to determine whether a system alteration was required, a response elicited 49.5 percent of the time, and (2) to check a newly installed system, a reason expressed 26.2 percent of the time. Other prevalent reasons included requirements for testing when selling the house (5.7 percent) or when the system was modified (5.4 percent). The reason mentioned least often was that the test was done to assess the water's quality after a system failure or malfunction (0.4 percent).

Tests of water quality were most often requested by members of the household (approximately 58 percent of tests). Far less frequent were requests by local governmental officials (11.6 percent of the most recent tests), contractors (7.9 percent), and state officials (6.4 percent). Government at all levels and mandatory testing requirements were involved in about 30 percent of the responses, but the majority of the tests were a consequence of household members exercising their own initiative.

Many tests that had been performed on the household water—in 53.0 percent of households testing—were done to assess bacteriological content. This figure represented bacteriological investigations that were conducted independently or in conjunction with a chemical testing procedure. Separate chemical tests were done in 14 percent of households, while chemical tests were done jointly with bacteriological tests in 24.8 percent of households. In another 33 percent of the households, it was not known what type of test had been performed.

Of the bacteriological tests that had been performed in the past, 3.1 percent indicated unacceptable levels of biological contaminants, according to the verbal reports from the households. Moreover, although 52.3 percent of the households reported that the level of bacteria was within the particular standard that was being applied, about 44.5 percent did not know the test results. This same pattern existed in the data pertaining to chemical tests, where about 64 percent of the households did not know the result for any given constituent. When the results were known, the water of most households contained acceptable levels of the chemicals that are typically detected. In fact, of the seventeen constituents inquired about, only six were ever reported as being present in excessive quantities. These chemicals and the proportion of households reporting them as unacceptable were: iron 5.5 percent, nitrate 1.4 percent, sulfur 0.6 percent, calcium 0.3 percent, sodium 0.3 percent, and arsenic 0.2 percent. For a complete list of this set of constituents, see question C-9 of the interview schedule, which is presented as Appendix A.

— Summary, Water test history

On the basis of the historical evidence, water testing of households with individual systems is done fairly often in rural America. The tests appear to be conducted intermittently rather than on a regular basis, however, and occur most often in response to a suspected difficulty with the water supply or to satisfy some mandatory testing requirement. Among types of quality tests, those that examine the bacteriological content are the most common, although a substantial proportion of the tests include procedures for detecting certain chemicals as well as the presence of bacteria. Perhaps the most intriguing aspect of water testing of individual systems is the unexpectedly large proportion of households that have no knowledge of the type of test that is performed or the test results. This suggests that the information obtained from tests is being intentionally or unintentionally ignored, or that government agencies and the other organizations involved in water testing notify the household members only if the results indicate that the water is abnormal. Independent of the potential causes of this problem, its implication is that an insufficient number of rural households with individual systems know the condition of their water supplies.

Regional variation in individual systems

Regional variation in general reference features of individual systems

Although groundwater was the predominant source for individual systems in all regions of rural America, its use was more prominent in some regions than in others. The general trends in regional variation had some resemblance to those described in Chapter IV for the sources of all major household supplies regardless of size of system, but groundwater was even more prevalent as a source for individual systems in all regions since wells were so common among individual systems.

As can be seen in Table VII-15, groundwater was used as the source most often in the Northeast and North Central. It was also used frequently in the South and West, but in the South, precipitation and purchased bottled or hauled water were used more often than in other regions. In the West, surface water was used more than seven times as frequently than in any other region except the Northeast. (That small portion of groundwater-supplied systems which used springs is presented on a regional basis in Table VII-22.)

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Table VII-15

Regional Variation in Source, Ownership, and Length of Service Among Individual Water Systems

	Number and Percent of Systems				
Characteristic	Nation	Northeast	North Central	South	West
Source					
Groundwater	8,168,000 93.2%	1,631,000 95.8%	3,254,000 95.9%	2,766,000 89.9%	518,000 87.4%
Precipitation	133,000 1.5%	12,000 0.7%	29,000 0.9%	92,000 3.0%	0 0.0%
Surface water	93,000 1.1%	26,000 1.5%	6,000 0.2%	14,000 0.4%	48,000 8.0%
Purchased bottled, or hauled	371,000 4.2%	35,000 2.0%	105,000 3.1%	204,000 6.6%	27,000 4.6%
Total	8,765,000 100.0%	1,703,000 100.0%	3,394,000 100.1%	3,075,000 100.0%	593,000 99.9%
Ownership					
Individual	8,505,000 97.0%	1,670,000 98.1%	3,284,000 96.8%	3,006,000 97.7%	545,000 91.9%
Private firm	101,000 1.1%	20,000 1.1%	39,000 1.1%	23,000 0.8%	19,000 3.2%
Public	69,000 0.8%	0 0.0%	32,000 0.9%	30,000 1.0%	6,000 1.1%
Cooperative	16,000 0.2%	0 0.0%	9,000 0.3%	0 0.0%	6,000 1.1%
Indian tribe	16,000 0.2%	0 0.0%	0 0.0%	0 0.0%	16,000 2.7%
No owner	18,000 0.2%	6,000 0.4%	6,000 0.2%	6,000 0.2%	0 0.0%
Other	41,000 0.5%	7,000 0.4%	24,000 0.7%	10,000 0.3%	0 0.0%
Total	8,765,000 100.0%	1,703,000 100.0%	3,394,000 100.0%	3,075,000 100.0%	593,000 100.0%

Table VII-15 continued

Characteristic	Number and Percent of Systems Nation	 Northeast	 North Central	 South	 West
Number of years served by system					
Up to 5	3,886,000 44.3%	683,000 40.1%	1,625,000 47.9%	1,285,000 41.8%	292,000 49.3%
6 - 10	1,586,000 18.1%	301,000 17.7%	592,000 17.4%	605,000 19.7%	88,000 14.9%
11 - 20	1,632,000 18.6%	359,000 21.1%	540,000 15.9%	610,000 19.8%	124,000 20.9%
21 - 50	1,556,000 17.8%	350,000 20.5%	598,000 17.6%	525,000 17.1%	83,000 14.0%
More than 50	100,000 1.1%	11,000 0.6%	39,000 1.2%	50,000 1.6%	0 0.0%
Could not be determined	5,000 0.1%	0 0.0%	0 0.0%	0 0.0%	5,000 0.9%
Total	8,765,000 100.0%	1,703,000 100.0%	3,394,000 100.0%	3,075,000 100.0%	593,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

As to ownership of individual systems, the national pattern remained fairly consistent throughout all regions. One exception was that ownership by individuals was less prevalent in the West (Table VII-15).

The length of time during which households were served by the system also showed only modest variation. The shortest period of service (from less than one through five years) occurred more often in the West and North Central than in the other two regions. Conversely, longer periods of service were particularly prominent in the Northeast, where about 20 percent of the households had been served for 21 through 50 years. This apparent trend also was evident in the median length of service time in the different regions. Median length of time served by the system was 8 years and 7.5 years in households in the Northeast and South, respectively. In contrast, the median length of service was 6.1 years in North Central households and 5.5 years in Western households. The trends paralleled relative differences in length of residency in rural America, since the median period of residency was greater in the Northeast and South than in the West or North Central (see Chapter III).

Regional variation in engineering and sanitary features of individual wells

— Regional variation in sites of wellheads

The general siting and wellhead arrangements of individual systems with wells varied considerably by region. Examination of Table VII-16 reveals that whereas about 60 percent of all individual wells in rural America terminated above ground, the proportion was smaller in the North Central and Northeast (strikingly smaller in the latter region, where a large proportion of wells were buried). The proportion was notably greater in the South, where 77.0 percent of individual wells terminated above ground.

As to well pits, their use was proportionately greatest in the West and least in the South. Wellheads were buried much more often in the Northeast than in

Table VII-16

Regional Variation in Wellhead Arrangements for Individual Wells

Classification	Number and Percent of Systems Nation	Northeast	North Central	South	West
Terminated above ground					
Protected (by shed, roof, or other structure)	3,510,000 44.5%	511,000 33.9%	1,120,000 34.6%	1,620,000 61.6%	259,000 50.6%
Uncovered	1,187,000 15.0%	193,000 12.8%	528,000 16.3%	407,000 15.4%	60,000 11.7%
Subtotal	4,697,000 59.5%	704,000 46.7%	1,648,000 50.9%	2,027,000 77.0%	318,000 62.3%
Situated in well pit					
Pit without water-tight cover	808,000 10.2%	136,000 9.0%	512,000 15.8%	90,000 3.4%	69,000 13.6%
Pit with water-tight cover	558,000 7.1%	124,000 8.2%	207,000 6.4%	172,000 6.5%	56,000 10.9%
Pit with no cover	27,000 0.3%	0 0.0%	0 0.0%	27,000 1.0%	0 0.0%
Subtotal	1,393,000 17.6%	260,000 17.2%	719,000 22.2%	288,000 10.9%	125,000 24.5%
Buried	1,387,000 17.6%	467,000 31.0%	625,000 19.3%	245,000 9.3%	49,000 9.7%
Situated in household	293,000 3.7%	39,000 2.6%	202,000 6.2%	33,000 1.3%	18,000 3.6%
Miscellaneous arrangements	28,000 0.4%	11,000 0.7%	17,000 0.5%	0 0.0%	0 0.0%
Arrangements could not be determined	96,000 1.2%	28,000 1.9%	30,000 0.9%	38,000 1.4%	0 0.0%
Total	7,893,000 100.0%	1,509,000 100.1%	3,241,000 100.0%	2,632,000 99.9%	512,000 100.1%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

other regions. The contrast was striking: nearly one-third of all wells were buried in the Northeast, compared to about one-tenth of wells in the South and West.

As to pit drainage (not presented in Table VII-16), the proportions of pits without any drainage increased steadily across regions from east to west. The proportion of pits without drainage was about 46 percent in the Northeast, 57 percent in the North Central, 67 percent in the South, and 36 percent in the West. When there was drainage, it most often was to open ground in each region, as it was from about 34 percent of all well pits in the Northeast, 25 percent of pits in the North Central, 18 percent of pits in the South, and 15 percent of pits in the West.

— Regional variation in construction of individual wells

Generally, the type of well construction was fairly consistent in rural America, regardless of regional location (Table VII-17). There were some regional differences, however. For example, as expected, drilled wells were most prevalent in the West and Northeast, where underlying rock formations have always posed problems for other construction methods. Driven wells were most common in the North Central, where aquifers could be reached relatively easily through the type of sand or gravel appropriate for driven-well techniques. Bored and jetted wells also require sand, gravel, or other soil without large rocks, and thus it was not surprising to discover that both types of wells were proportionately most common in the South, where there are favorable conditions in the Atlantic and Gulf Coastal Plain, a large groundwater region which extends across the entire Southeast.

Although type of well construction generally coincided with what was anticipated on the basis of regional geology, this was not so for dug wells. Dug wells were expected to be most prominent in the South and North Central, where soil conditions and aquifer location seemed most favorable. Yet the proportion of

Table VII-17

Regional Variation in Construction of Individual Wells

	Number and Percent of Systems				
Type of Construction	Nation	Northeast	North Central	South	West
Drilled	4,560,000 57.7%	927,000 61.4%	1,801,000 55.6%	1,501,000 57.0%	331,000 64.7%
Driven	1,001,000 12.7%	150,000 9.9%	587,000 18.1%	215,000 8.2%	49,000 9.6%
Dug	985,000 12.5%	250,000 16.5%	264,000 8.2%	387,000 14.7%	85,000 16.6%
Bored	407,000 5.2%	10,000 0.7%	93,000 2.9%	289,000 11.0%	15,000 2.9%
Jetted	91,000 1.2%	5,000 0.3%	40,000 1.2%	46,000 1.8%	0 0.0%
Could not be determined	847,000 10.7%	167,000 11.1%	456,000 14.1%	193,000 7.3%	32,000 6.2%
Total	7,893,000 100.0%	1,509,000 99.9%	3,241,000 100.1%	2,632,000 100.0%	512,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

dug wells was largest in the Northeast and West, even though dug wells in the South outnumbered those in any other region.

— Regional variation in age of individual wells

As can be seen in Table VII-18, wells tended to be newer in the West than in the other regions, as determined by time since construction or alteration of wells. The West had the largest proportion of wells that were less than six years old, and so was reflected in the median age of wells in the region (5.9 years). The median age of wells in each of the other regions ranged from 7.9 years through 8.8 years, a difference of less than one year.

— Regional variation in depth of individual wells

Varying depths of individual wells showed similar proportions for each of the four regions (Table VII-19). . One exception, however, was that extremely shallow wells (less than 10 feet deep) were most common in the Northeast (6.3 percent) and least common in the South (0.6 percent). According to the EPA, shallow wells are more likely to be contaminated since the depth is insufficient for percolation.[15] Moreover, a higher proportion of wells in the West and South than in the Northeast were in the 10-15 meters depth category. The median depth of wells was very similar across all regions: wells ranged from about 23 meters (75 feet) in the West through 29 meters (95 feet) in the Northeast.

— Regional variation in casing diameter of individual wells

The comparative prevalence of smaller-diameter, standard-size casing was notable in the North Central. For example, 13.2 percent of all individual drilled, driven, bored, or jetted wells in the rural North Central had a casing diameter of 5.1 centimeters (two inches); 16.4 percent had a casing diameter of 10.2 centimeters (four inches). The comparative percentages elsewhere for these two sizes

Table VII-18

Regional Variation in Age of Individual Wells

Age (Number of Years Since Construction or Alteration)	Number and Percent of Systems				
	Nation	Northeast	North Central	South	West
5 or less	2,683,000 34.1%	464,000 30.8%	1,060,000 32.7%	939,000 35.7%	220,000 42.9%
6 - 10	1,453,000 18.4%	329,000 21.8%	630,000 19.5%	414,000 15.7%	80,000 15.7%
11 - 15	906,000 11.5%	213,000 14.1%	244,000 7.4%	389,000 14.9%	60,000 11.9%
16 - 20	588,000 7.5%	95,000 6.3%	302,000 9.3%	170,000 6.4%	21,000 4.1%
21 - 50	1,109,000 14.0%	274,000 15.8%	413,000 12.8%	389,000 14.9%	68,000 13.3%
More than 50	171,000 2.2%	42,000 2.8%	92,000 2.8%	24,000 0.9%	12,000 2.4%
Could not be determined	984,000 12.4%	127,000 8.4%	450,000 15.4%	307,000 11.6%	50,000 9.7%
Total	7,893,000 100.1%	1,509,000 100.0%	3,241,000 100.0%	2,632,000 100.1%	512,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-19

Regional Variation in Depth of Individual Wells

	Number and Percent of Systems				
Depth in Meters (Feet)*	Nation	Northeast	North Central	South	West
3 or less (less than 10)	153,000 1.9%	96,000 6.3%	28,000 0.9%	14,000 0.6%	14,000 2.8%
4-9 (11-30)	909,000 11.5%	181,000 12.1%	429,000 13.2%	251,000 9.5%	48,000 9.2%
10-15 (31-50)	945,000 12.0%	80,000 5.3%	324,000 10.0%	427,000 16.2%	114,000 22.2%
16-21 (51-70)	846,000 10.9%	133,000 8.8%	350,000 10.8%	314,000 12.0%	58,000 11.2%
22-30 (71-100)	1,268,000 16.1%	240,000 15.9%	538,000 16.6%	413,000 15.8%	77,000 15.1%
31-61 (101-200)	2,011,000 25.5%	429,000 28.4%	801,000 24.7%	658,000 25.0%	124,000 24.2%
62-91 (201-300)	477,000 5.9%	100,000 6.6%	196,000 6.1%	139,000 5.3%	42,000 8.2%
92-122 (301-400)	200,000 2.5%	37,000 2.5%	81,000 2.5%	66,000 2.5%	15,000 3.0%
123-152 (401-500)	82,000 1.1%	7,000 0.5%	9,000 0.3%	56,000 2.1%	10,000 1.9%
153-330 (501-1,082)	54,000 0.7%	0 0.0%	37,000 1.1%	18,000 0.7%	0 0.0%
Unaccounted for	11,000 0.1%	0 0.0%	0 0.0%	11,000 0.4%	0 0.0%
Could not be determined	927,000 11.8%	205,000 13.6%	449,000 13.8%	263,000 10.0%	11,000 2.2%
Total	7,893,000 100.0%	1,509,000 100.0%	3,241,000 100.0%	2,632,000 100.1%	512,000 100.0%

*Depths were measured in meters; parenthetical conversions to feet are rough approximations.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

of casings were, respectively, 1.9 and 4.9 percent in the Northeast; 12.0 and 7.4 percent in the South; and 0.0 and 1.4 percent in the West.

The occurrence of larger casings in the West was clear in another comparison. Fully 77.1 percent of all individual drilled, driven, bored, or jetted wells in the West had casings which were 15.2 centimeters (six inches) or larger in diameter. Comparable percentages in the other regions were 62.5 percent in the Northeast, 48.9 percent in the South, and only 25.7 percent in the North Central.

Although casing diameters ranged to more than 76.2 centimeters (30 inches), 20.3-centimeter (eight-inch) diameter casings were the largest found in relatively important proportions. In the West, 13.7 percent of all casings were this large. Comparable percentages elsewhere were 16.9 percent in the Northeast, 5.0 percent in the South, and only 2.1 percent in the North Central.

— Regional variation in grouting of individual wells

Grouting status for drilled, driven, bored, or jetted wells in the Northeast and the North Central was the same as for wells in the nation as a whole. That is, about 39 percent of the wells were not grouted, about 35 percent were grouted, and grouting status for the other 26 percent could not be determined.

The situation was somewhat different, however, in the South and West. In the South, a larger proportion of wells—40.4 percent—were grouted, but about the same proportion—41 percent—were ungrouted. To balance, the proportion of wells for which grouting status could not be determined declined to 18.6 percent in the South. In the West, the proportion of wells of undetermined grouting status rose slightly—to 28.6 percent—but the proportion of wells without grouting fell sharply—to 29.6 percent, or about nine percentage points less than the proportion in the nation as a whole. Correspondingly, the proportion of wells in the West with grouting—41.8 percent—was larger than in any other region.

— Regional variation in wellhead sealing against pollutants

When the NSA data on adequacy of wellhead sealing were organized by region, clear and sometimes contrary differences were discovered (Table VII-20). The data for the nation as a whole were reflected closely only in the Northeast. In contrast, the proportion of wells with covers which met the NSA criteria for general acceptability was considerably larger in the North Central than in any other region, and somewhat smaller in the West than in any other region. By the same token, unacceptable covers were proportionately least common in the North Central, most common in the West.

The proportion of wells with splashproof covers also was greater in the North Central than in the other regions, and the proportion of wells without such protection was greater in the South and West than in the other two regions. Although wells in the West, compared to those in other regions, generally were in less satisfactory condition in terms of adequacy of cover arrangements, the Western wells generally were in the most satisfactory condition in terms of source protection.

Overall, then, individual wells in rural areas of the North Central were in superior condition in terms of wellhead sealing. Wells in the West and South generally were in the poorest condition in this regard, except that source protection against pollution was superior in Western wells. The combined evaluation of wellhead sealing and source protection, which tabulated ratings on all three factors together, showed that the South had the largest proportion of individual wells that were unacceptable with respect to all three factors (16.4 percent).

— Regional variation in distance to potential pollution sources for individual wells

The distance between wellhead and some potential pollution sources varied from region to region, but the number of systems for which measurements were available generally was so small that it could not be determined if the differences

Table VII-20

Regional Variation in Adequacy of Wellhead Sealing and Source Protection of Individual Wells

Characteristic	Number and Percent of Systems				
	Nation	Northeast	North Central	South	West
Cover (general acceptability)					
Acceptable	5,808,000 73.6%	1,059,000 70.2%	2,633,000 81.2%	1,792,000 68.1%	323,000 63.2%
Unacceptable	1,752,000 22.2%	380,000 25.2%	485,000 15.0%	717,000 27.2%	170,000 33.3%
Could not be determined	334,000 4.2%	70,000 4.6%	123,000 3.8%	123,000 4.7%	18,000 3.5%
Total	7,893,000 100.0%	1,509,000 100.0%	3,241,000 100.0%	2,632,000 100.0%	512,000 100.0%
Cover (splashproof or not)					
Splashproof	5,896,000 74.7%	1,131,000 74.9%	2,678,000 82.6%	1,716,000 65.2%	371,000 72.5%
Not splashproof	1,562,000 19.8%	250,000 16.5%	427,000 13.2%	757,000 28.8%	128,000 25.0%
Could not be determined	397,000 5.0%	108,000 7.2%	136,000 4.2%	140,000 5.3%	13,000 2.5%
Not applicable	39,000 0.5%	20,000 1.3%	0 0.0%	19,000 0.7%	0 0.0%
Total	7,893,000 100.0%	1,509,000 99.9%	3,241,000 100.0%	2,632,000 100.0%	512,000 100.0%
Source protection					
Adequately protected	5,930,000 75.1%	1,129,000 74.8%	2,616,000 80.7%	1,744,000 66.3%	441,000 86.3%
Not adequately protected	1,598,000 20.2%	305,000 20.2%	461,000 14.2%	781,000 29.7%	51,000 10.0%
Could not be determined	365,000 4.6%	75,000 5.0%	164,000 5.1%	106,000 4.0%	19,000 3.7%
Total	7,893,000 99.9%	1,509,000 100.0%	3,241,000 100.0%	2,632,000 100.0%	512,000 100.0%

Table VII-20 continued

Characteristic	Nation	Northeast	North Central	South	West
	Number and Percent of Systems				
Combined Evaluation					
Acceptable on all three factors	4,925,000 62.4%	907,000 60.1%	2,296,000 70.8%	1,417,000 53.8%	305,000 59.7%
Unacceptable on one factor	746,000 9.5%	165,000 11.0%	276,000 8.5%	244,000 9.3%	62,000 12.1%
Unacceptable on two factors	679,000 8.6%	106,000 7.0%	200,000 6.2%	305,000 11.6%	67,000 13.1%
Unacceptable on all three factors	870,000 11.0%	182,000 12.1%	216,000 6.7%	432,000 16.4%	40,000 7.9%
Could not be determined	673,000 8.5%	149,000 9.9%	254,000 7.8%	234,000 8.9%	37,000 7.3%
Total	7,893,400 100.0%	1,509,000 100.1%	3,241,000 100.0%	2,632,000 100.0%	512,000 100.1%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

were meaningful. In two instances, however, there was some evidence that potential problems from pollution were more serious in one region than in others. In the first instance, in the Northeast, the median distance from wells to surface water contamination was eighteen meters (59.1 feet), compared to more than 30 meters (98.4 feet) for wells in each of the other regions. In the second instance, in the West, the median distance from wells to a source of animal waste was 11.9 meters (39 feet), compared to 59.5 meters (195.2 feet) in the Northeast, 24.8 meters (81.4 feet) in the North Central, and eighteen meters (59 feet) in the South. Concurrently, 15 percent of all individual wells in the West were less than sixteen meters from animal waste, compared to 9.1 percent in the South, 7.9 percent in the North Central, and 4.4 percent in the Northeast.

— Regional variation in access to well equipment (pitless adapter, buried seal)

As seen in Table VII-21, the proportion of individual wells with pitless adapters was particularly low in the West and South; the proportions in those two regions were each about half the proportion in the North Central, and barely more than half the proportion in the Northeast. This finding was consistent with the use of pitless adapters in colder climates which produce subsurface frost, a problem which the pitless adapter circumvents (see Figure VII-11).

On the other hand, the proportion of buried seals was greatest in the Northeast and smallest in the South and West. On balance, then, the wellhead access arrangements in the Northeast (despite the large proportion of pitless adapters there) may have presented the most potential for pollution since the use of the buried seal was more prominent there than in other regions, and since the lack of pitless adapter or buried seal (the "neither" category in Table VII-21) in Southern and Western wells did not necessarily imply pollution-prone access arrangements (see earlier discussion of national findings).

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Table VII-21

Regional Variation in Use of Pitless Adapter, Buried Seal in All Individual Well Systems

Installation	Number and Percent of Systems Nation	 Northeast	 North Central	 South	 West
Pitless adapter	2,278,000 28.9%	480,000 31.8%	1,233,000 38.0%	475,000 18.0%	91,000 17.8%
Buried seal	1,547,000 19.6%	479,000 31.7%	666,000 20.5%	328,000 12.5%	74,000 14.5%
Neither	3,840,000 48.7%	531,000 35.2%	1,186,000 36.6%	1,778,000 67.6%	346,000 67.7%
Could not be determined	227,000 2.9%	19,000 1.3%	157,000 4.9%	51,000 2.0%	0 0.0%
Total	7,893,000 100.1%	1,509,000 100.0%	3,241,000 100.0%	2,632,000 100.1%	512,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Regional variation in features of individual spring systems

Individual spring systems were not common in rural America, as can be seen in Table VII-22. Nearly all of the spring systems were either in the Northeast or in the South.

Because of the predominance of spring systems in the Northeast or South, statistical data on the features of rural springs referred almost entirely to spring systems in those two regions. This meant that the numbers of springs in the North Central and West were so small that reliability was lessened for comparisons about intrusion protection related to acceptable covers and adequate source protection. With this qualification in mind, the NSA data indicated that springs in the North Central tended to be better protected than elsewhere: about 62 percent of the covers were considered acceptable, and all of the springs were considered to have adequately protected sources. In sharp contrast, all of the spring systems in the West were considered to have unacceptable covers and to be inadequately protected.

In the South, the proportion of spring systems with unacceptable covers (59 percent) was considerably smaller than in the Northeast (75.9 percent). At the same time, the proportion of Southern spring systems with acceptable covers (41 percent) was much larger than the proportion of spring systems in the Northeast with acceptable covers (19.2 percent); the relevant status of the balance of 4.9 percent of Northeast wells could not be determined. Similarly, protection of the source was acceptable for a larger proportion of spring systems in the South than in the Northeast (45.3 percent versus 34.8 percent).

As to regional variation in distance from a potential pollution source, information generally was restricted to systems in the Northeast and South, where most of the spring systems were located. In focusing on the data for the Northeast and the South, spring systems in the Northeast generally appeared to have more potential problems than systems in the South in terms of proximity to possible

Table VII-22
Regional Distribution of Individual Springs

Statistic	Nation	Northeast	North Central	South	West
Number of individual springs	275,000	122,000	12,000	134,000	6,000
Percent of individual springs	100.0	44.5	4.4	48.9	2.2

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

pollution sources. That is, about 22 percent of Northeast spring systems were less than 30 meters (98.4 feet) from a sewage disposal system; about 8 percent were less than 30 meters from an oil or gasoline tank; about 4 percent were less than 30 meters from highway salt; and about 4 percent were less than 30 meters from other sources of contamination. In each situation, the proportion was larger than the respective national proportion (see Table VII-8) and larger than the respective Southern proportion. In the South, only the proportion of spring systems closer than 30 meters to animal waste (13 percent) was larger than the proportion in the Northeast (4.9 percent).

Regional variation in features of individual cistern systems

Potential pollution problems with individual cistern systems tended to be proportionately greater in the Northeast than in the other regions. For example, as seen in Table VII-23, the Northeast had the largest proportions of cistern systems without first-water diverters or with unacceptable covers. None of the cisterns in the Northeast or in the North Central had drains. (Cisterns were not encountered in the West, as indicated in Table VII-15.)

Different patterns of regional variation occurred with respect to other pollution-related considerations. All of the 6,000 cistern systems with inadequate source protection were located in the South. As to distance from a pollution source, the proportion of cisterns less than 16 meters (52.5 feet) from a sewage disposal system was greater in the Northeast than elsewhere: all of the Northeastern cisterns, compared to 18.7 percent of all Southern cisterns, were this close to a sewage disposal system. On the other hand, all of the cistern systems which were immediately next to animal waste or surface water contamination were in the South (6.2 percent and 12.4 percent of all Southern cistern systems, respectively).

Table VII-23

Regional Variation in Structural Characteristics of Individual Cisterns

Characteristic	Nation	Northeast	North Central	South	West*
	Number and Percent of Systems				
First-water diverter					
No diverter	78,000 58.7%	12,000 100.0%	10,000 32.8%	57,000 61.7%	- -
Manual diverter	49,000 37.0%	0 0.0%	20,000 67.2%	30,000 32.1%	- -
Automatic diverter	6,000 4.3%	0 0.0%	0 0.0%	6,000 6.2%	- -
Total	133,000 100.0%	12,000 100.0%	29,000 100.0%	92,000 100.0%	- -
Cleaning drain					
No drain	101,000 76.0%	12,000 100.0%	29,000 100.0%	60,000 65.3%	- -
Drain present	22,000 16.1%	0 0.0%	0 0.0%	22,000 23.3%	- -
Could not be determined	10,000 7.9%	0 0.0%	0 0.0%	10,000 11.4%	- -
Total	133,000 100.0%	12,000 100.0%	29,000 100.0%	92,000 100.0%	- -
Location of catchment area					
On the roof	133,000 100.0%	12,000 100.0%	29,000 100.0%	92,000 100.0%	- -
Total	133,000 100.0%	12,000 100.0%	29,000 100.0%	92,000 100.0%	- -

Table VII-23 continued

	Number and Percent of Systems				
Characteristic	Nation	Northeast	North Central	South	West*
Cover (general acceptability)					
Acceptable	83,000 62.4%	6,000 51.9%	29,000 100.0%	48,000 51.8%	- -
Unacceptable	41,000 30.4%	6,000 48.1%	0 0.0%	35,000 37.8%	- -
Could not be determined	10,000 7.1%	0 0.0%	0 0.0%	10,000 10.3%	- -
Total	133,000 99.9%	12,000 100.0%	29,000 100.0%	92,000 99.9%	- -

*The NSA sample included no cistern systems in the West.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Regional variation in features of individual surface water systems

As reported earlier in relation to the data in Table VII-15, individual surface water systems, although comparatively rare in the nation as a whole, were considerably more numerous in the West than in other regions. In terms of sanitary protection, individual surface water systems in the West had adequate source protection more often than those in other regions. Surface water sources were adequately protected against pollution in fully 80 percent of all Western systems. In contrast, none of the systems in any of the other regions had adequately protected sources.

As to distance from potential pollution sources, however, surface water systems in the West were in less satisfactory condition than those elsewhere in terms of nearness to animal waste. About 62 percent of all Western systems were ten meters (32.8 feet) or less from animal waste. The situation was little better in the South, however, where about 52 percent of surface water systems were so close to animal waste that the distance was recorded as zero. In the Northeast, on the other hand, the main problem was not nearness to animal waste, but rather to a sewage disposal system or to an oil or gasoline tank. About 25 percent of all Northeastern systems (6,000 systems) were only two meters (6.6 feet) from a sewage disposal system. The same percentage of Northeastern systems were only two meters from an oil or gasoline tank.

Summary of regional variation in sanitary-related construction features of individual systems

As measured by the limited number of features studied in the NSA, the sanitary condition of individual rural systems varied from region to region. The variation changed somewhat according to the type of system being studied. For example, as to wells, the status of those in the North Central appeared to be more favorable than in other regions in terms of acceptable, splashproof well covers.

The North Central wells also were grouted nearly as often as those in other regions, and they had adequately protected sources more often than in any region except the West. Southern wells, in contrast, were least often equipped with acceptable, splashproof covers, and they had adequately protected sources less frequently than well systems in other regions. Wells in the Northeast more often had buried seals than wells elsewhere, and they tended to be closer to surface water pollution than did wells in other regions. Overall, then, adequate sanitary-related construction features tended to be most prevalent in North Central wells, least prevalent in Southern and Northeastern wells.

Likewise, the sanitary-construction status of North Central spring systems also seemed comparatively superior to the status of springs elsewhere, but the numbers of such systems in the North Central and West were small in comparison to the numbers in the South and Northeast (Table VII-22). When the status of spring systems in the South was compared to that of systems in the Northeast, the Southern systems generally had superior features. However, the superiority was only a relative one, since the majority of systems in the South had unacceptable covers and inadequate source protection.

In regard to cisterns, comparisons could be made only for three regions, since cisterns were not encountered in the West in the NSA survey. Among the other three regions, the Northeast had the largest proportion of cistern systems with inadequate sanitary features (see Table VII-23).

As to surface water systems, those in the West (where 51 percent of the individual surface water systems were located) had much better source protection than those in the other regions. However, surface water systems in the West and South tended to be located closer to animal waste than did systems elsewhere. Systems in the Northeast were sometimes closer to a sewage disposal system or to an oil or gasoline tank than were systems elsewhere.

Regional variation in general system considerations for all individual systems

At this point, the focus once again shifts back to certain general considerations relevant to all individual systems, whatever the supply source. The considerations are the methods for transporting water from the supply to the household, the types of water processing and treatment devices in the system, the availability of free assistance or advice regarding the system, and the history of laboratory testing of water in the system. The objective is to determine regional variations in findings involving these considerations.

— Regional variation in methods for bringing water into the household

Water for the major household supply was propelled to the household by electric pump in most individual systems in every region of the US. In fact, in all regions except the South, the proportions of systems with electric pumps surpassed the national figure of 91 percent. In the South, however, the proportion of systems with electric pumps was notably lower—84.4 percent. Although this proportion was still very large, other, less advanced techniques for transporting water were much more prominent in the South than in other regions. For example, water was carried by hand from the source to the household in 8.5 percent of Southern systems, and water was hauled in another 3 percent of Southern systems. These proportions were considerably larger than the respective ones in other regions. In fact, 77 percent of all individual systems in the US that relied on hand-carrying of water, and 68 percent of all individual systems where water was hauled, were located in the South. This amounted to 263,000 hand-carried systems and 93,000 hauled systems in the South.

— Regional variation in types of water distribution and treatment devices

As seen in Table VII-24, the proportions of systems with various water distribution and treatment devices were fairly similar in the different regions. One

Table VII-24

Regional Variation in Presence of Water Distribution and Treatment Devices in Individual Systems

	Number and Percent of Systems*				
Device	Nation	Northeast	North Central	South	West
Pump	8,107,000 92.5%	1,627,000 95.5%	3,290,000 97.0%	2,630,000 85.5%	589,000 94.4%
Pressure tank	7,817,000 89.2%	1,607,000 94.3%	3,118,000 91.9%	2,558,000 83.2%	535,000 90.2%
Storage tank	683,000 7.8%	143,000 8.4%	285,000 8.4%	209,000 6.8%	45,000 7.6%
Settling tank	28,000 0.3%	13,000 0.8%	6,000 0.2%	0 0%	10,000 1.6%
Activated carbon or anthracite filter	92,000 1.0%	23,000 1.3%	18,000 0.5%	40,000 1.3%	11,000 1.8%
Chlorinator	74,000 0.8%	15,000 0.9%	40,000 1.2%	19,000 0.6%	0 0.0%
Phosphate feeder	33,000 0.4%	27,000 1.6%	0 0.0%	6,000 0.2%	0 0.0%
Oxidation filter	102,000 1.2%	20,000 1.2%	75,000 2.2%	7,000 0.2%	0 0.0%
Softener	1,544,000 17.6%	216,000 12.7%	1,160,000 34.2%	116,000 3.8%	52,000 8.8%
Miscellaneous filters	291,000 3.3%	42,000 2.5%	63,000 1.9%	144,000 4.7%	42,000 7.1%
Other devices	117,000 1.3%	5,000 0.3%	76,000 2.2%	15,000 0.5%	21,000 3.6%
Total Systems	8,765,000	1,703,000	3,394,000	3,075,000	593,000

*Table reports systems having at least one device; percentages are based on the number of individual systems in the rural US and in the respective regions, regardless of supply type.

prominent exception was that the proportion of systems with water softeners was decisively larger in the North Central than in the other regions. In fact, about 75 percent of all softeners in individual systems in the rural US were in the North Central. This finding was consistent with the discovery that the median hardness value in the major supplies of the North Central was larger than for any other region, and more than twice the value for the nation as a whole (see Chapter V). (As noted in Chapter V, hardness was measured in specimens from the cold water tap, whereas water softeners generally served the hot water line. Thus, the degree of hardness and the use of softeners were determined independently.)

The greater proportion of miscellaneous filters in Western systems was consistent with household reports of more sediment in Western supplies than in supplies elsewhere (see Chapter V).

— Regional variation in free advice or assistance for individual systems

The proportions of individual rural systems receiving specific types of free advice or assistance did not vary greatly among regions. Thus, the proportions in each region generally were quite close to those for the nation as a whole (national data were presented previously in Table VII-12).

The source of the advice or assistance showed slightly more variation in different regions. The most notable example of this was in the West, where "an individual" provided the free aid for fully 40 percent of those systems for which such aid was received (a total of 52,000 out of the 130,000 systems receiving aid). In contrast, individuals provided the aid for only 12.4 percent of North Central systems for which such aid was received. Comparable percentages for the Northeast and South were 20 percent and 25.5 percent, respectively.

In the North Central, on the other hand, water softening companies provided the aid for nearly 22 percent of systems receiving such aid, more than twice the percentage in any other region. At the same time, North Central systems were the only ones for which free aid was received from either cooperative extension sources or from the EPA.

— Regional variation in water test history for individual systems

NSA findings showed that except for the South, regions had only slight differences in the proportions of individual-system households that had had water tests done prior to the NSA. The South was conspicuous in that water tests had been conducted in only 27.6 percent of the households, compared to an average of about 42 percent in the other three regions. The lower incidence of testing in the South was principally responsible for reducing the national average to 37 percent, as reported earlier in this chapter.

In regard to the frequency of testing, there was substantial variation across regions, particularly with respect to the maximum number of tests performed on a household's water supply and the proportion of households in any one region reporting more than four prior tests. For example, in the Northeast and North Central, small proportions of households had 70 or 80 tests done, respectively, while the maximum number of tests mentioned in the South was fifteen. Multiple tests were lowest in the West, where only about 5 percent of households indicated that four tests had been performed. No households in the West had had more than four tests conducted, while the Northeast contained the largest proportion of households that had had more than four tests (7.4 percent).

The regional historical trends in water testing, presented in Table VII-25, displayed some slight disparities. Although the regions showed approximately equal proportions of households tested since 1960, the Northeast and South had substantially larger proportions tested than the other two regions in the period between 1960 and 1969, and noticeably smaller proportions tested in the most recent decade. Considerably smaller proportions of the households in the Northeast and South reported that their water had been tested before 1960, compared to the

Table VII-25

Regional Variation in Year of Most Recent Water Quality Test Among Individual Systems

	Number and Percent of Systems					
Region	Before 1930	1930-39	1940-49	1950-59	1960-69	1970-79
Northeast	0 0.0%	0 0.0%	11,600 1.5%	38,010 3.1%	178,080 23.2%	503,320 65.4%
North Central	5,770 0.4%	0 0.0%	34,840 2.5%	104,800 7.5%	157,440 11.7%	1,036,760 74.0%
South	0 0.0%	0 0.0%	6,890 0.8%	53,080 6.4%	167,870 19.7%	527,580 62.1%
West	0 0.0%	5,270 2.2%	5,270 2.2%	16,910 7.2%	35,370 15.0%	165,560 70.0%

North Central and West. Other than these differences, the results were quite similar to the national estimates, which were reported earlier in this chapter. On the whole, these findings suggested that water testing began earlier in the North Central and West, although the Northeast and South eventually attained parity by increasing their testing activity.

The reasons for performing a test of the household water also varied from region to region, with perhaps the largest difference observed between the West and the other three regions. For example, an average of about 77 percent of the households in the Northeast, North Central, and South reported that a water test had been conducted to determine if the system was operating properly after its initial installation or to determine if the system had to be modified. In the West, these reasons were noted by only 61.5 percent of the households. The only other striking regional difference was that households that had had their water tested to verify its quality after a system breakdown were located exclusively in the South.

The information on who had requested the past water tests reflected some substantial regional differences. In fact, the only consistent result was that in all regions, tests were requested most often by household members; further, the proportions of tests initiated by someone in the household were very similar—varying only between 56.0 and 63 percent in the four regions. Representatives of local governments tended to be somewhat more active in the South, where they initiated 15.9 percent of the tests, in comparison to the Northeast, where local officials had requested only 8.8 percent of the tests. Another regional pattern was that in the Northeast, contractors had requested 14 percent of past tests, a much greater proportion than the 7.8 percent in the South, the 5.7 percent in the North Central, or the 2.2 percent in the West.

As to the specific type of the most recent water quality test, there was considerable variation in each of the regions except the West, where the proportion of households with bacteriological tests, either singly or in combination with chemical tests, and the proportion of households with chemical tests, either singly or in combination with bacteriological tests, were both similar to the proportions for the nation as a whole. In the Northeast, on the other hand, the proportion of households with single or combined bacteriological tests was 63.6 percent—compared to 53.0 percent for the nation—and the proportion of households with single or combined chemical tests was 51.4 percent—compared to 38.8 percent for the nation. In the North Central, 41.4 percent of households had bacteriological tests, and 47.0 percent had chemical tests. In the South, 49.1 percent of households had bacteriological tests, but only 23.3 percent had chemical tests. The most prominent differences, then, were in the Northeast, where testing—particularly bacteriological—was more common than in other regions, and in the South, where chemical testing was much less common than in other regions.

The results of the prior bacteriological tests demonstrated that, proportionately, slightly more individual supply systems in the West contained unacceptable levels of bacteria. Bacterial concentrations in excess of the applicable standard were detected in about 5.1 percent of the individual supply systems that had been tested in the West, while the comparable figure for the North Central was only 1.7 percent. In both the Northeast and the South, excessive bacteria were found in approximately 4 percent of the prior tests.

The Northeast was the only region in which acceptable levels of bacteria (within the applicable standard) were present in more than 65 percent of the tests: less than 53 percent of the tests that had been done on supply systems in each of the other three regions showed acceptable levels. However, the proportions of households in each region that had no knowledge of the bacteriological test results ranged from 51.1 percent in the North Central to 28.6 percent in the Northeast.

Chemical tests on individual systems produced findings for iron, sulfur, nitrates, arsenic, calcium, and sodium. Iron was the most common chemical constituent reported in all of the regions. Levels of iron exceeded the applicable standard in 8.8 percent of the specimens assayed in the Northeast, 5.3 percent in the South, 4.1 percent in the West, and 3.3 percent in the North Central. Although a total of six constituents were detected by tests done across all regions, only in the North Central were more than four chemicals found to occur in concentrations greater than the standard in effect when the test was performed.

In summary, the water test histories of households that obtained their water from individual supply systems differed according to the region in which they were located. In the South, for example, the incidence of water testing was low relative to the other regions. Routine and regular testing of water supplies appeared to be more characteristic in the Northeast and North Central, although even in these regions most testing was not done on a repetitive basis.

The overall level of testing activity was approximately the same over the past twenty years, but testing occurred earlier on the average in the North Central and West. Since a substantially smaller proportion of the households in the West reported that their water had been tested to assess whether a system alteration were necessary or if the system were operating properly after its initial installation, the West also was somewhat different in terms of the reasons for the tests. A much larger proportion of households in the Northeast tested for bacteriological contamination and chemical contamination, though the incidence of chemical tests was less frequent.

SMSA/nonSMSA variation in individual systems

SMSA/nonSMSA variation in general reference features of individual systems

As can be seen in Table VII-26, there were no notable differences in the general reference features of SMSA versus nonSMSA individual systems. The sources were similar for systems in the two categories. Ownership was similar, although there was more variety in ownership among nonSMSA systems, which far outnumbered SMSA systems. One difference which is not presented in the table is

Table VII-26

SMSA/NonSMSA Variation in Source, Ownership, and Length of Service Among Individual Water Systems

Characteristic	Number and Percent of Systems SMSA	 NonSMSA
Source		
Groundwater	2,223,000 94.3%	5,945,000 92.8%
Precipitation	35,000 1.5%	98,000 1.5%
Surface water	35,000 1.5%	58,000 0.9%
Purchased bottled, or hauled	65,000 2.8%	306,000 4.8%
Total	2,358,000 100.1%	6,407,000 100.0%
Ownership		
Individual	2,293,000 97.2%	6,213,000 96.9%
Private firm	45,000 1.9%	56,000 0.9%
Public	2,000 0.1%	66,000 1.0%
Cooperative	0 0.0%	16,000 0.2%
Indian tribe	0 0.0%	16,000 0.2%
No owner	0 0.0%	18,000 0.3%
Other	18,000 0.8%	22,000 0.3%
Total	2,358,000 100.0%	6,407,000 99.8%

Table VII-26 continued

Characteristic	Number and Percent of Systems	
	SMSA	NonSMSA
Number of years served by system		
Up to 5	1,117,000 47.4%	2,768,000 43.2%
6 - 10	498,000 21.1%	1,088,000 17.0%
11 - 20	387,000 16.4%	1,245,000 19.4%
21 - 50	329,000 14.0%	1,226,000 19.1%
More than 50	26,000 1.1%	74,000 1.2%
Could not be determined	0 0.0%	5,000 0.1%
Total	2,358,000 100.0%	6,407,000 100.0%

that, despite the similarity in proportions of systems with individual ownership, that ownership was held by someone outside of the household for 8.8 percent of SMSA systems, compared to 16 percent of nonSMSA systems. The length of time during which households were served by the system was also similar for SMSA and nonSMSA systems, and therefore approximately the national average of about 7 years.

SMSA/nonSMSA variation in engineering and sanitary features of individual wells

— SMSA/nonSMSA variation in sites of wellheads

The general siting and wellhead arrangements of individual systems with wells (a total of 7,893,000 systems, as detailed previously) were similar for both SMSA and nonSMSA systems. The arrangements thus were similar to those for the nation as a whole (see Table VII-2). However, there were several SMSA versus nonSMSA differences worth noting. First, the proportion of individual wells which terminated above ground and which were protected by a shed or other structure was greater outside of SMSAs (46.3 percent) than within SMSAs (39.7 percent). The proportion of buried wells, on the other hand, was greater inside SMSAs (23.8 percent) than outside SMSAs (15.2 percent). These differences are consistent with the greater restriction of space inside SMSAs, which frequently are near urban areas. To use a generalized example, locating an individual wellhead in a pumphouse some distance from the household is more appropriate on a nonSMSA farm than in an SMSA housing development. In addition, local ordinances or local conventions might be less favorable toward use of pumphouses within SMSAs than outside of SMSAs.

— SMSA/nonSMSA variation in construction of individual wells

The type of well construction did not vary greatly in SMSA versus nonSMSA systems, and the construction therefore generally was similar to that in the nation as a whole (see Table VII-3). One exception was that the proportion of dug wells was considerably larger for nonSMSA systems than for SMSA systems—14.3 percent versus 8 percent. The dug wells generally are least favored in terms of their sanitary features, and there may have been more social or regulatory pressure to limit their use within SMSAs than outside of SMSAs.

— SMSA/nonSMSA variation in age of wells, depth of wells, casing diameter, and grouting

The proportion of well systems in successive age categories was similar inside and outside of SMSAs, and the proportions thus were similar to those in the nation (see Table VII-4). Likewise, SMSA and nonSMSA wells were about the same age as represented by the median: individual nonSMSA well systems were nine years old and SMSA well systems were 7.2 years.

The proportion of well systems in successive depth categories also was similar inside and outside of SMSAs. This similarity was also conveyed by the median well depth which was 27.3 meters, or 89.6 feet, for SMSA wells; and 26.3 meters, or 86.3 feet, for nonSMSA wells. Casing diameters were also similar for SMSA and nonSMSA individual well systems.

Again, the proportions of wells with and without grouting was similar in SMSA and nonSMSA systems. Specifically, 38.2 percent and 33.2 percent of the relevant SMSA and nonSMSA wells, respectively, were grouted; and 41.0 percent and 37.8 percent, respectively, were not grouted. Information about grouting could not be obtained for the remaining wells.

— SMSA/nonSMSA variation in wellhead sealing against pollutants

General acceptability of well covers was similar inside and outside of SMSAs, the findings for both approximating those for the nation as a whole (see Table VII-6). However, the proportion of well systems with covers which had specific splashproof protection (see discussion of national findings for a definition) was larger inside SMSAs than outside of SMSAs. The results for SMSA systems showed that about 81 percent of systems had splashproof covers, about 12 percent did not, and about 8 percent could not be assessed in this regard. In contrast, about 73 percent of nonSMSA well systems had acceptable splashproofing, 23 percent did not, and about 5 percent could not be assessed.

In terms of source protection, SMSA systems also were better protected than nonSMSA systems. About 82 percent of SMSA systems had adequate source protection. This was nine percentage points higher than for nonSMSA well systems. At the same time, 13 percent of SMSA systems had inadequate source protection. This was ten percentage points lower than for nonSMSA systems. The combined evaluation, which linked particular wells' ratings on the three separate factors related to wellhead sealing, showed that roughly two-thirds of individual wells both inside and outside SMSAs were judged acceptable on all three factors. However, about 13 percent of nonSMSA wells, compared to 5.8 percent of SMSA wells, were unacceptable on all three factors.

— SMSA/nonSMSA variation in distance to potential pollution sources

The distance between individual wells and possible pollution sources varied somewhat according to whether the system was located inside or outside of an SMSA. However, median distances varied by no more than ten meters (about 33 feet), and none of the median distances was less than sixteen meters (the general reference point for an acceptable distance, as explained in the national findings in this chapter).

— SMSA/nonSMSA variation in access to well equipment (pitless adapter, buried seal)

The use of pitless adapters showed some variation between SMSA and nonSMSA well systems. The adapters were found in about 35 percent of individual well systems within SMSAs, compared to about 26 percent of systems outside of SMSAs. However, buried seals also were more prevalent inside SMSAs—in about 26 percent of SMSA systems as opposed to approximately 17 percent of nonSMSA systems. In about 53 percent of nonSMSA systems, compared to about 37 percent of SMSA systems, neither device was present.

In summary, a larger proportion of SMSA systems had pitless adapters, which offered the best arrangement in terms of convenience and sanitation. On the other hand, a smaller proportion of nonSMSA systems had buried seals, devices which have serious drawbacks, as discussed previously in this chapter. A larger proportion of nonSMSA systems had neither pitless adapter nor buried seal. This was consistent with the potential for larger household property—on a farm, for example—outside of SMSAs. The additional property might make it easier to use a pumphouse or other arrangement instead of a pitless adapter or buried seal arrangement; on the other hand, pumphouse arrangements might not be acceptable to local ordinances or local conventions inside SMSAs.

SMSA/nonSMSA variation in features of individual spring systems

In terms of intrusion protection as indicated by acceptable covers and source protection, nonSMSA spring systems generally were superior. Covers were acceptable for about 33 percent of nonSMSA spring systems, compared to only about 15 percent of SMSA spring systems. Source protection was adequate for about 45 percent of nonSMSA spring systems, compared to approximately 15 percent of SMSA systems. Although a larger proportion of nonSMSA spring systems had superior intrusion protection, the advantage clearly was only a relative one.

That is, the majority of springs, whether inside or outside of SMSAs, were not adequately protected against influx of pollutants.

As to variation in distance from potential pollution sources, there were two noteworthy comparisons. First, the median distance between springs and sewage disposal systems was about 60 meters (196.9 feet) outside of SMSAs, as opposed to about 27 meters (88.6 feet) within SMSAs. Second, the median distance between springs and potential sources of surface pollution was about 23 meters (75.5 feet) inside SMSAs, compared to only 0.7 meters (2.3 feet) outside of SMSAs. In both cases, the median distance was calculated only for springs for which measurements were available. As pointed out earlier in the discussion of the national findings, the potential surface pollution most likely was the spring itself, which could be contaminated by surface pollutants if the spring were inadequately protected.

SMSA/nonSMSA variation in features of individual cistern systems

As seen in Table VII-27, the profile of individual cistern structural characteristics was different in SMSA systems as opposed to nonSMSA systems. A first-water diverter was installed in about 53 percent of SMSA systems, compared to about 37 percent of nonSMSA systems. Although SMSA systems more often were superior in that regard, they were not as often adequate in regard to cleaning drains or acceptable covers. In fact, none of the SMSA cisterns for which the determination could be made had drains.

As to distance from potential pollution sources, the numbers of SMSA systems for which information was available was too small for meaningful comparisons between SMSA and nonSMSA systems.

SMSA/nonSMSA variation in features of surface water systems

As was true for cisterns, the number of SMSA surface water systems was too small for meaningful comparisons between SMSA and nonSMSA surface water

Table VII-27

SMSA/NonSMSA Variation in Structural Characteristics of Individual Cisterns

	Number and Percent of Systems	
Characteristic	SMSA	NonSMSA
First-water diverter		
No diverter	16,000 46.9%	62,000 62.9%
Manual diverter	19,000 53.1%	31,000 31.2%
Automatic diverter	0 0.0%	6,000 5.8%
Total	35,000 100.0%	98,000 99.9%
Cleaning drain		
No drain	30,000 86.5%	71,000 72.2%
Drain present	0 0.0%	22,000 21.9%
Could not be determined	5,000 13.5%	6,000 5.8%
Total	35,000 100.0%	98,000 99.9%
Cover (general acceptability)		
Acceptable	20,000 56.9%	63,000 64.4%
Unacceptable	6,000 16.1%	35,000 35.6%
Could not be determined	10,000 27.0%	0 0.0%
Total	35,000 100.0%	98,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

systems. The only condition which could be compared was the adequacy of source protection (see discussion of national findings for definition). In that regard, there was a sharp contrast. Nearly 73 percent of the 35,000 SMSA surface water systems had adequately protected sources; about 27 percent did not. The situation was almost exactly the opposite for nonSMSA systems: only 22 percent of the 58,000 nonSMSA systems had adequately protected sources; 78 percent did not.

SMSA/nonSMSA variation in general system considerations for all individual systems

As to methods for bringing water into the household (the first of the general considerations taken up in this section), the electric pump provided motive force in most SMSA and nonSMSA systems—in about 9[illegible] percent of the former and 89 percent of the latter. This was true for all systems regardless of type. However, the proportions reveal that whereas nearly all SMSA systems used pumps for transport to the household, other methods were employed for about 10 percent of nonSMSA systems. Those methods included gravity flow arrangements in 2 percent of nonSMSA systems, hand-carrying arrangements in 5 percent of nonSMSA systems, and hauling arrangements in about 2 percent of nonSMSA systems. The comparable percentages for the respective SMSA systems were each less than 1 percent.

As to SMSA/nonSMSA variation in types of water distribution and treatment devices, the proportions of various devices for both SMSA and nonSMSA systems were similar to those for the nation (Table VII-11), except for a few devices. One noteworthy difference was that whereas about 28 percent of SMSA individual systems had a water softener, only about 14 percent of nonSMSA systems—only half the percentage of SMSA systems.

As to SMSA/nonSMSA variation in free advice or assistance for individual systems, there was little difference in the proportions of SMSA systems versus nonSMSA systems receiving specific types of free aid, and the proportions were similar to those listed for the nation in Table VII-12.

Although there was practically no variation between SMSA and nonSMSA systems in terms of types of free aid, there was considerable variation in the sources of the aid. As seen in Table VII-28, the proportion of SMSA systems (37.8 percent) obtaining aid from local government agencies was considerably larger than the proportion of nonSMSA systems (22.6 percent) obtaining aid from this source. On the other hand, the proportion of nonSMSA systems (24.3 percent) receiving aid from individuals was considerably larger than the proportion of SMSA systems (9.1 percent) receiving aid from this source. Other prominent differences were that water softening companies provided aid about twice as often to SMSA systems as to nonSMSA systems (the proportions were 21.3 percent and 10.8 percent, respectively), and that state health departments provided aid to nonSMSA systems more often than to SMSA systems (the proportions were 13.9 percent and 8.7 percent, respectively). Also, only nonSMSA systems received aid from cooperative extension sources, the EPA, the Farmers Home Administration, and state environmental departments.

SMSA/nonSMSA variation in water test history for individual systems

Water quality testing in households served by individual systems occurred somewhat more often in SMSA than in nonSMSA households. Specifically, at least one test had been performed in 43 percent of the former households and in 35 percent of the latter. Testing had not been done in 54.1 percent and in 59.6 percent of SMSA and nonSMSA households, respectively, and it was not known whether testing had been done in 2.9 percent and in 5.4 percent of SMSA and nonSMSA households, respectively.

SMSA households also were generally likely to have had more tests than nonSMSA households. For example, more than two tests had been performed at

Table VII-28

SMSA/NonSMSA Variation in Source of Free Assistance or Advice Received by Individual Systems

	Number and Percent of Systems	
Source	SMSA	NonSMSA
Local government agency	212,000 37.8%	307,000 22.6%
An individual	51,000 9.1%	330,000 24.3%
Water softening company	119,000 21.3%	147,000 10.8%
State health department	49,000 8.7%	188,000 13.9%
Miscellaneous	57,000 10.1%	151,000 11.1%
Large chain store	21,000 3.7%	32,000 2.4%
Local building contractor	9,000 1.6%	28,000 2.1%
Cooperative extension	0 0.0%	30,000 2.2%
Local plumbing company	7,000 1.2%	7,000 0.5%
US Environmental Protection Agency	0 0.0%	13,000 1.0%
Farmers Home Administration	0 0.0%	6,000 0.4%
State environmental department	0 0.0%	5,000 0.4%
Could not be determined	36,000 6.5%	112,000 8.3%
Total	560,000 100.0%	1,356,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

23.6 percent of the one million SMSA households in which testing had been done. In contrast, more than two tests had been performed at only 13.3 percent of the 2.2 million nonSMSA households in which testing had been done. Furthermore, 3.2 percent of the SMSA households had had more than 40 tests—1.3 percent had had 80. In contrast, no more than 28 tests had occurred at any of the nonSMSA households. In some households, either the number of tests was not known, or else the number could not be determined because the tests had been done before the residency of the current occupants. This situation occurred in 5.3 percent of SMSA households and in 4.6 percent of nonSMSA households. Historical trends in water testing, as indicated by the decade in which the last test was done, were approximately the same for SMSA and nonSMSA households (see Table VII-14).

The various reasons for performing the last test were similar in SMSA and nonSMSA households, and the reasons thus paralleled those reported for households in the nation as a whole (see section in this chapter titled "Individual system water test history").

Requests for the tests generally came from similar sources, whether the tests were performed in SMSA or in nonSMSA households (see "Individual system water test history" earlier in this chapter). The only notable difference in the request sources was that local officials had requested tests in 15.1 percent of the SMSA households compared to 10.1 percent of the nonSMSA households.

As to extensiveness of the testing, combined bacteriological and chemical testing was more likely to have occurred in SMSA households than in nonSMSA households (33.5 percent versus 20.9 percent). Bacteriological tests alone were done in 24.8 percent of SMSA households in which testing was done, and in 29.7 percent of nonSMSA households. Chemical tests alone were performed in 16.0 percent of SMSA households and in 13.1 percent of nonSMSA households. The type of testing was not known in 36.3 percent of nonSMSA households and in 25.7 percent of SMSA households.

In regard to the results of the last test, the reported results indicated that both bacteriological and chemical water quality in SMSA households was superior to that in nonSMSA households. Bacteriological results were acceptable in 63.3 percent of the SMSA households and in 47.4 percent of the nonSMSA households. Finally, test results were not known in 35.2 percent of SMSA households and in 48.7 percent of nonSMSA households. Levels of bacteria which were examined were found to be unacceptable in 1.4 percent of SMSA households, as opposed to 3.9 percent of nonSMSA households.

As to the chemical tests, only one of the seventeen constituents inquired about was found in unacceptable levels at SMSA households. That constituent was iron, which was in unacceptable concentrations at 4.8 percent of SMSA households. The condition was similar at nonSMSA households: iron was reported to be in unacceptable levels at 5.8 percent of nonSMSA households. The levels of five other constituents were found to be unacceptable only in the following proportions of nonSMSA households: sulfur, 0.9 percent; arsenic, 0.3 percent; calcium, 0.4 percent; nitrate, 2.1 percent; and sodium, 0.4 percent.

To summarize the overall test history, the situation generally was better at SMSA households than at nonSMSA households. That is, water quality testing had been done in a larger proportion of SMSA households, and when testing had been done, the actual number of tests performed was likely to be largest in SMSA households. Furthermore, based on the most recent test performed, the testing was likely to be most comprehensive in SMSA households. That is, bacteriological and chemical testing combined—as opposed to one or the other individually—occurred most often in SMSA households. Finally, the results of the tests indicated that water quality was somewhat better in SMSA households. The most recent chemical test results were unacceptable for six constituents in nonSMSA households, but only for one constituent in SMSA households.

Size-of-place variation in individual systems

Size-of-place variation in general reference features of individual systems

As seen in Table VII-29, most individual systems were located in other rural areas. In fact, the proportion of systems in other rural areas was so large that the percentage distributions of other-rural-area systems in various categories usually determined the percentage distributions for the nation as a whole. Specifically, about 96 percent of all individual systems were in other rural areas, 3 percent were in small rural communities, and only 1 percent were in large rural communities. In terms of source and ownership, there was considerably more variety among the arrangements for systems in other rural areas than elsewhere. Thus, precipitation and surface water were sources for individual systems only in other rural areas. This finding was expected, since use of cisterns and surface water has been associated with open country areas, which occur most often in other rural areas. The larger proportionate use of purchased bottled or hauled water for the major individual supplies in large rural communities, on the other hand, was in keeping with availability of community-based sources such as public water supplies which could be used for hauled water.

A number of types of ownership occurred only in systems located in other rural areas. Although most systems were owned by individuals, the relation of the individuals to the households was different in the different places (not reflected in Table VII-29). While none of the individual owners in large rural communities resided outside of the households, about 14 percent of individual owners in small communities and other rural areas were from outside the households.

The data in Table VII-29 show that whereas the majority of large-rural-community systems were in service for more than ten years, the majority of small-rural-community and other-rural-areas systems were in service for ten years or less. The median length of service was thirteen years in large communities, compared to 9.8 years in small communities and seven years in other rural areas.

Table VII-29

Size-of-Place Variation in Source, Ownership, and Length of Service Among Individual Water Systems

	Number and Percent of Systems			
Characteristic	Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
Source				
Groundwater	8,168,000 93.2%	104,000 90.2%	206,000 97.3%	7,858,000 93.1%
Precipitation	133,000 1.5%	0 0.0%	0 0.0%	133,000 1.6%
Surface water	93,000 1.1%	0 0.0%	0 0.0%	93,000 1.1%
Purchased bottled, or hauled	371,000 4.2%	11,000 9.8%	6,000 2.7%	354,000 4.2%
Total	8,765,000 100.0%	116,000 100.0%	212,000 100.0%	8,438,000 100.0%
Ownership				
Individual	8,505,000 97.0%	104,000 90.2%	212,000 100.0%	8,189,000 97.0%
Private firm	101,000 1.1%	11,000 9.8%	0 0.0%	89,000 1.1%
Public	69,000 0.8%	0 0.0%	0 0.0%	69,000 0.8%
Cooperative	16,000 0.2%	0 0.0%	0 0.0%	16,000 0.2%
Indian tribe	16,000 0.2%	0 0.0%	0 0.0%	16,000 0.2%
No owner	18,000 0.2%	0 0.0%	0 0.0%	18,000 0.2%
Other	41,000 0.5%	0 0.0%	0 0.0%	41,000 0.5%
Total	8,765,000 100.0%	116,000 100.0%	212,000 100.0%	8,438,000 100.0%

Table VII-29 continued

Characteristic	Number and Percent of Systems Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
Number of years served by system				
Up to 5	3,886,000 44.3%	40,000 34.4%	64,000 30.3%	3,782,000 44.8%
6 - 10	1,586,000 18.1%	6,000 5.0%	43,000 20.2%	1,538,000 18.2%
11 - 20	1,632,000 18.6%	47,000 40.5%	57,000 26.8%	1,528,000 18.1%
21 - 50	1,556,000 17.8%	16,000 13.7%	48,000 22.7%	1,492,000 17.7%
More than 50	100,000 1.1%	7,000 6.4%	0 0.0%	92,000 1.1%
Could not be determined	5,000 0.1%	0 0.0%	0 0.0%	5,000 0.1%
Total	8,765,000 100.0%	116,000 100.0%	212,000 100.0%	8,438,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

As to systems with very long periods of service (more than 50 years), the largest proportion of such systems occurred in large rural communities. Despite this, the longest period of service in large rural communities was 58 years. In contrast, the longest period of service in other rural areas was 75 years.

Size-of-place variation in engineering and sanitary features of individual wells

— Size-of-place variation in sites of wellheads

The general wellhead arrangements of individual systems did not differ strikingly by size of place, but there were variations among certain features. For example, as seen in Table VII-30, a smaller proportion of systems terminated above ground in small rural communities than in large communities or other rural areas, and the proportion of small-rural-community systems with uncovered wellheads was particularly small. At the same time, the proportion of small-rural-community systems located in pits with watertight covers was larger than for wells in the other places. Wellheads were buried least frequently in large rural communities, and about equally as often in small communities as in other rural areas.

— Size-of-place variation in construction of individual wells

As was true for other size-of-place findings, those associated with system construction in other rural areas determined the percentage distributions for the nation. Also, bored wells (numbering 407,000) and jetted wells (numbering 91,000) were found only in other rural areas. The proportion of driven wells, however, was much greater in large rural communities (about 42 percent of wells there) than in small communities or in other rural places (about 10 and 12 percent of wells in those places, respectively). In contrast, the proportion of drilled wells was considerably smaller in large communities (about 38 percent of wells there) than in small communities or other rural areas (about 60 and 58 percent of wells in those places, respectively).

Table VII-30

Size-of-Place Variation in Wellhead Arrangements for Individual Wells

Classification	Number and Percent of Systems			
	Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
Terminated above ground				
Protected (by shed, roof, or other structure)	3,510,000 44.5%	35,000 33.2%	74,000 35.8%	3,401,000 44.9%
Uncovered	1,187,000 15.0%	22,000 20.7%	20,000 9.5%	1,146,000 15.1%
Subtotal	4,697,000 59.5%	57,000 53.9%	94,000 45.3%	4,548,000 60.0%
Situated in well pit				
Pit without water-tight cover	808,000 10.2%	19,000 18.6%	18,000 8.9%	770,000 10.2%
Pit with water-tight cover	558,000 7.1%	8,000 8.1%	30,000 14.6%	520,000 6.9%
Pit with no cover	27,000 0.3%	0 0.0%	0 0.0%	27,000 0.4%
Subtotal	1,393,000 17.6%	28,000 26.7%	49,000 23.5%	1,316,000 17.5%
Buried	1,387,000 17.6%	13,000 12.3%	37,000 17.9%	1,338,000 17.6%
Situated in household	293,000 3.7%	7,000 7.1%	14,000 6.7%	272,000 3.6%
Miscellaneous arrangements	28,000 0.4%	0 0.0%	0 0.0%	28,000 0.4%
Arrangements could not be determined	96,000 1.2%	0 0.0%	14,000 6.6%	82,000 1.1%
Total	7,893,000 100.0%	104,000 100.0%	206,000 100.0%	7,583,000 100.2%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

— Size-of-place variation in age of individual wells

Well age (as determined by the number of years since construction or alteration of the well) showed some pronounced differences in places of different size. The most striking difference was in the findings for wells aged 21 through 50 years. About 35 percent of all individual wells in small rural communities were in this age bracket, compared to about 3 percent of all individual wells in large rural communities, and about 14 percent of all individual wells in other rural areas. Median well age among the places showed the same order of ranking. That is, the median age of wells was about fourteen years in small rural communities, ten years in large rural communities, and eight years in other rural areas.

— Size-of-place variation in depth of wells, casing diameter, and grouting

The median depth of wells varied somewhat in places of different size, but the variations were modest. Median depth of wells for which the information could be obtained was 26.8 meters (87.9 feet) in other rural areas, 24.4 meters (80 feet) in large rural communities, and 22.4 meters (73.5 feet) in small rural communities. The range of well depths had a more pronounced pattern. The extent of the range was smallest in large rural communities, largest in other rural areas. Specifically, the range was from ten meters (32.8 feet) or less through 60 meters (196.9 feet) in large rural communities; from ten meters or less through 170 meters (557.7 feet) in small rural communities; and from ten meters or less through 330 meters (1,082.7 feet) in other rural areas.

The size-of-place comparison for casing diameter indicated the prevalence of certain standard even-size casing everywhere, but also revealed some sharp differences in casing size. Excluding the large proportions in every place-size category which could not provide information, individual casing diameter for drilled, driven, bored, or jetted wells also increased among the three categories. Equally large proportions of wells in large rural communities had casing diameters of 10.2 centimeters (four inches) and 5.4 centimeters (two inches), while casing diameters of 10.2 centimeters were proportionately more common in small community wells. In other rural areas, fully 30 percent of the wells had casing diameters of 15.2 centimeters (six inches).

Determination of size-of-place variation in grouting status for drilled, driven, bored, or jetted wells was hampered because the status could not be determined for 43.1 percent of wells in large communities and 45.1 percent of wells in small communities—as opposed to 25.9 percent of wells in other rural areas. Grouting was known to be installed in only 6.7 percent of large-community individual wells, compared to 20.1 percent of small-community wells and 35.5 percent of other-rural-area wells.

— Size-of-place variation in wellhead sealing against pollutants

Adequacy of wellhead sealing was dissimilar in the three size-of-place categories (Table VII-31). The condition of systems in other rural areas was nearly the same as the condition of systems in the nation as a whole (Table VII-6). That is, about three-quarters of all other-rural-area individual well systems had generally acceptable, splashproof covers and adequate source protection. This proportion declined slightly for small-rural-community well systems in terms of acceptable covers; in terms of adequate source protection and splashproof covers, the proportion dropped off even more.

The variation was particularly striking for large-rural-community well systems. All of those systems had generally acceptable covers, but about 17 percent of the covers were not splashproof. About 41 percent of the well systems had inadequate source protection. As to the combined evaluation of wellhead sealing, the most conspicuous finding was the comparatively large proportion of wells in small rural communities which were rated unacceptable on all three factors.

Table VII-31

Size-of-Place Variation in Adequacy of Wellhead Sealing and Source Protection of Individual Wells

Characteristic	Number and Percent of Systems		
	Large Rural Communities	Small Rural Communities	Other Rural Areas
Cover (general acceptability)			
Acceptable	104,000 100.0%	142,000 69.0%	5,561,000 73.3%
Unacceptable	0 0.0%	50,000 24.4%	1,701,000 22.4%
Could not be determined	0 0.0%	14,000 6.6%	320,000 4.2%
Total	104,000 100.0%	206,000 100.0%	7,583,000 99.9%
Cover (splashproof or not)			
Splashproof	87,000 83.1%	127,000 61.4%	5,683,000 74.9%
Not splashproof	18,000 16.9%	60,000 29.3%	1,483,000 19.6%
Could not be determined	0 0.0%	19,000 9.3%	417,000 5.5%
Total	104,000 100.0%	206,000 100.0%	7,583,000 100.0%
Source protection			
Adequately protected	61,000 58.8%	135,000 65.4%	5,734,000 75.6%
Not adequately protected	43,000 41.2%	50,000 24.4%	1,504,000 19.8%
Could not be determined	0 0.0%	21,000 10.2%	344,000 4.5%
Total	104,000 100.0%	206,000 100.0%	7,583,000 99.9%

Table VII-31 continued

Characteristic	Number and Percent of Systems Large Rural Communities	 Small Rural Communities	 Other Rural Areas
Combined evaluation			
Acceptable on all three factors	61,000 58.8%	113,000 55.0%	4,750,000 62.6%
Unacceptable on one factor	25,000 24.4%	14,000 6.7%	707,000 9.3%
Unacceptable on two factors	18,000 16.9%	15,000 7.4%	646,000 8.5%
Unacceptable on all three factors	0 0.0%	37,000 18.0%	833,000 11.0%
Could not be determined	0 0.0%	27,000 12.9%	647,000 8.5%
Total	104,000 100.1%	206,000 100.0%	7,583,000 99.9%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

— Size-of-place variation in distance to potential pollution sources for individual wells

Median distances between individual wells and various sources of possible pollution were similar for the nation (Table VII-7) and for other rural areas. Some of the medians were different in large and small rural communities than in other rural areas, however. Of particular note, the median distance between large-rural-community individual wells and oil or gasoline tanks (for the 16 percent of systems for which distances were determined) was 12.3 meters (40.4 feet). This was about three meters (9.8 feet) less than the minimum distance recommended by the EPA (see report on national findings in this chapter). Median distance between large-rural-community individual wells and a potential source of surface water contamination was 10.2 meters (33.5 feet) for the 11 percent of systems for which measurements could be obtained.

As to small-rural-community individual well systems, median distance to a sewage disposal system was 14.4 meters (47.2 feet) for the 53.5 percent of systems for which measurements could be obtained. Median distance to an oil or gasoline tank was 10.9 meters (35.6 feet) for the 20.5 percent of systems for which measurements could be obtained.

— Size-of-place variation in access to well equipment (pitless adapter, buried seal)

Location by size-of-place had some effect on access equipment for wells terminating below ground, according to the NSA results. As seen in Table VII-32, large-rural-community individual well systems had the largest proportion of pitless adapters and the smallest proportion of buried seals. As with other size-of-place findings, the results for other rural areas were similar to those for the nation as a whole (national findings are presented in Table VII-21).

Table VII-32

Size-of-Place Variation in Use of Pitless Adapter and Buried Seal in Individual Wells

	Number and Percent of Systems		
Characteristic	Large Rural Communities	Small Rural Communities	Other Rural Areas
Pitless adapter	45,000 43.5%	59,000 28.6%	2,174,000 28.7%
Buried seal	13,000 12.3%	51,000 24.6%	1,484,000 19.6%
Neither	46,000 44.2%	75,000 36.6%	3,719,000 49.1%
Could not be determined	0 0.0%	21,000 10.2%	207,000 2.7%
Total	104,000 100.0%	206,000 100.0%	7,583,000 100.1%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Size-of-place variation in features of individual spring, surface, and cistern systems

All individual spring, surface, and cistern systems were located in other rural areas. Therefore, the profiles for those individual systems as already presented for the nation as a whole (earlier in this chapter) are the same as for systems in other rural areas.

Size-of-place variation in general system considerations for all individual systems

As in similar sections for the national, regional, and SMSA/nonSMSA findings, the focus here shifts from information about specific types of systems to certain general considerations relevant to all individual systems. The purpose is to determine if there is size-of-place variation in findings involving several considerations: methods for transporting water from the supply to the household, the types of water processing and treatment devices in the system, the availability of free assistance or advice regarding the system, and the history of laboratory testing of water in the system.

— Size-of-place variation in methods for bringing water into the household

There were a number of different methods for transporting water, ranging from use of an electric pump to carrying water by hand. However, the full range of methods occurred only in other-rural-area individual systems. As was true for size-of-place data generally, the information for systems in other rural areas coincided with that for systems in the nation as a whole (see discussion of national data earlier in this chapter).

The range of methods for bringing water into the household was much more restricted in large and small rural communities. In fact, propulsion by electric pump was the only method used in large-rural-community systems. The electric pump was used in 92.5 percent of small-community systems. Hand pumping and hand carrying were used in 2.1 percent (4,000) and 5.4 percent (11,000) of small-rural-community systems, respectively.

— Size-of-place variation in types of water distribution and treatment devices

The information about various devices in other rural areas (Table VII-33) is very similar to that for the nation as a whole (Table VII-11). As can be seen in Table VII-33, large rural communities were the only places in which all individual systems had pumps. This situation was consistent with the finding that water was always moved by pump power to large-rural-community households, although pumps were not necessarily used strictly for that purpose. That is, some of the more complex individual systems could have had several pumps to maintain system pressure or to direct water to other uses. In fact, 7.3 percent of individual systems in large rural communities (8,000 systems in all) had two pumps—a larger proportion of multiple-pump systems than in small communities or other rural areas (not reflected in Table VII-33).

— Size-of-place variation in free advice or assistance for individual systems

As seen in Table VII-34, some type of free advice or assistance was received far more often for individual systems in large rural communities than for systems in other places. Nearly two-thirds of all large-rural-community systems had received some type of aid: the actual proportion was almost three times that for systems in other rural areas. The individual proportions for systems in other rural areas were nearly the same as those for the nation as a whole since most of the systems were located in other rural areas, as noted frequently in this section.

As to the sources of the free aid, water softening companies provided the advice or assistance for about 33 percent of the large-rural-community systems receiving free aid; local government agencies provided the aid for about 30 percent

Table VII-33

Size-of-Place Variation in Presence of Water Distribution and Treatment Devices in Individual Systems

	Number and Percent of Systems*		
Device	Large Rural Communities	Small Rural Communities	Other Rural Areas
Pump	116,000 100.0%	202,000 95.2%	7,790,000 92.3%
Pressure tank	116,000 100.0%	183,000 86.3%	7,519,000 89.1%
Storage tank	11,000 9.8%	19,000 9.0%	652,000 7.7%
Settling tank	0 0.0%	0 0.0%	28,000 0.3%
Activated carbon or anthracite filter	0 0.0%	0 0.0%	92,000 1.1%
Chlorinator	0 0.0%	0 0.0%	74,000 0.9%
Phosphate feeder	0 0.0%	0 0.0%	33,000 0.4%
Oxidation filter	0 0.0%	0 0.0%	97,000 1.1%
Softener	27,000 23.7%	7,000 3.5%	1,509,000 17.9%
Miscellaneous filters	0 0.0%	20,000 9.2%	272,000 3.2%
Other devices	0 0.0%	0 0.0%	117,000 1.4%
Total Systems	116,000	212,000	8,438,000

*Table reports systems having at least one device; percentages are based on the number of individual systems in the rural US and in the respective size-of-place category, regardless of supply type.

Table VII-34

Size-of-Place Variation in Frequency of Individual Systems Receiving Free Advice or Assistance

Type of Advice or Assistance	Number and Percent of Systems		
	Large Rural Communities	Small Rural Communities	Other Rural Areas
Free chemical or biological test of water	52,000 45.1%	8,000 3.8%	1,503,000 17.8%
Help locating source of supply	17,000 14.6%	0 0.0%	201,000 2.4%
Information about building the system	0 0.0%	0 0.0%	114,000 1.4%
Information about altering the system	5,000 4.8%	0 0.0%	103,000 1.2%
Advice about finding site for system	6,000 5.0%	0 0.0%	48,000 0.6%
Other advice or assistance	0 0.0%	0 0.0%	38,000 0.5%
Any type*	75,000 64.7%	8,000 3.8%	1,845,000 21.9%
Total Systems	116,000	212,000	8,438,000

*Refers to number of systems receiving at least one type of advice or assistance. Since more than one type of aid could be received, number may be smaller than obtained by adding rest of column numbers.

of those systems; individuals provided the aid for about 23 percent of those systems; local building contractors provided the aid for about 7 percent of those systems; and the source of the aid could not be determined for about 7 percent of those systems.

The sources of free aid for other-rural-area systems were about the same as for systems in the nation as a whole, as presented in Table VII-13. Basically, there were more varied sources of free aid provided for other-rural-area systems than for large-rural-community systems. Also, unofficial sources—individuals, water softening companies, and local building contractors—were used less often for other-rural-area systems than for large-rural-community systems. In contrast, only miscellaneous sources were reported for free aid provided to small-rural-community systems.

Size-of-place variation in water test history for individual systems

Water quality testing in households served by individual systems was done much more often in large communities and in other rural areas than in small rural communities. At least one test had been performed in 44.4 percent of households (51,000) in large rural communities and in 37.5 percent of households (3,163,000) in other rural areas. In contrast, testing had been done at only 20.2 percent of households (43,000) in small rural communities. At the same time, testing had not been done in 55.6 percent of households in large communities, in 57.8 percent of households in other rural areas, in 71.9 percent of households in small communities. Although the testing status was known in all large-community households, it was not known in 7.9 percent of small-community households and in 4.7 percent of other-rural-area households.

Households in small rural communities also were likely to have had a smaller number of tests than households elsewhere, particularly other rural areas. Specifically, no more than one test was performed in the 43,000 small-community households in which testing was done. (In 17.7 percent of those households, however, the number of tests was not known, or else the number could not be determined because the tests had been done before the residency of the current occupants.) In the 51,000 large-community households in which tests were reported, one test had been performed in 54.4 percent of the households, and two tests had been performed in 45.6 percent. In the 5.2 million other-rural-area households tested, 83.1 percent had had two or fewer tests; 12.6 percent had had from three through 80 tests. In 4.3 percent of the households, however, the number of tests was not known, or else the number could not be ascertained because the tests were done before the residency of the current occupants.

Among households in other rural areas, historical trends in water testing (as indicated by the decade in which the last test was done) were very similar to trends portrayed for the nation in Table VII-14. The trends in households located in large communities and in small communities, on the other hand, were different from the national trend, but similar to each other. Specifically, the most recent test was performed from 1970 through 1979 in 55.8 percent of large-community households and in exactly the same proportion of small-community households—compared to 68.9 percent in other-rural-area households. The balance of the tests were performed from 1960 through 1969 in both large-community and small-community households—except that the test year was not known in 13.3 percent of the latter. In contrast, tests were performed before 1960 in 9.0 percent of households in other rural areas.

As to the reasons for the last test, the findings for households in other rural areas were similar to those for the nation as a whole. The findings for households in large communities and in small communities were distinctive, however. In large-community households, the most striking finding was that in 19.9 percent (a total of 10,000 households), the tests were performed because the water supply was suspected as the cause of someone's illness. This situation never occurred in small-community households, and it occurred in only 2.4 percent of other-rural-area households (a total of 76,000 households). In regard to other differences, the tests were done in 45.1 percent of households in large communities in order to check water quality after a system alteration. Comparable percentages were 0.0 percent in households in small communities and 4.8 percent in households in other rural areas. Although the tests were done to check newly installed water systems in 26.4 percent of other-rural-area households, this was the reason for the test in only 11.3 percent of large-community households, but in 30.9 percent of small-community households. Finally, the tests were performed in association with a house sale at 19.0 percent of households in small communities, at 5.6 percent of households in other rural areas, and at 0.0 percent of households in large communities. Reasons for the tests were known at all of the large-community households, but not at 19.0 percent of the small-community households nor at 4.0 percent of the other-rural-area households.

In other-rural-area households, the most recent tests were requested by various sources in proportions similar to those recorded for the nation as a whole. The situation was different in households in the other two size-of-place categories, although the largest proportion of households in all three categories had tests requested by members of the households (in 58.1 percent of households in other rural areas, 77.9 percent of households in large communities, and 32.3 percent of households in small communities). In 30.9 percent of small-rural-community households, contractors requested the tests. Comparable percentages in large-community and other-rural-area households were 10.8 percent and 7.6 percent, respectively. In addition to household members and contractors, local officials were the only other sources of requests in large-community households (in 11.3 percent), whereas other sources in small-community households were local officials (in 17.8 percent) and federal officials (in 19.0 percent).

As to the type of test, the findings for the nation and for other rural areas were very similar, as seen in Table VII-35. In particular, bacteriological tests, or bacteriological and chemical tests combined, were more common than chemical tests in other-rural-area households. The findings for the other two size-of-place categories were different, however. In small-rural-community households, *only* bacteriological tests were reported, but the proportion of households (82.3 percent) in which the type of test was unknown was very large. In large-rural-community households, separate chemical and bacteriological tests were conducted in nearly equal proportions (roughly one-third of the households there).

In regard to the results of the last test, the small proportions of households known to have unacceptable results for either bacteriological or chemical tests generally were in households located in other rural areas. The levels of seven constituents were unacceptable in the following proportions of other-rural-area households: bacteria, 3.2 percent; iron, 4.9 percent; sulfur, 0.6 percent; arsenic, 0.2 percent; calcium, 0.3 percent; nitrate, 1.4 percent; sodium, 0.3 percent. The results were acceptable, or else unknown, for the other eleven constituents in households in all size-of-place classifications. Among all of the constituents, only iron was in unacceptable concentrations in households which were not in other rural areas. Specifically, concentrations of iron were unacceptable in 50.7 percent of large-community households (17,000). Although the test results appeared to be most favorable in households in small rural communities, the situation was not that clear-cut. The problem was that the results were unknown in large proportions of those households.

Summarization of water test history trends among households in different size-of-place categories is difficult because the findings are dominated by results in the other-rural-area category. That is, 96.3 percent of the 8,765,000 households served by individual systems were in other rural areas, 2.4 percent were in small rural communities, and 1.3 percent were in large rural communities. The test

Table VII-35

Size-of-Place Variation in Type of Water Quality Tests in Households Served by Individual Systems

	Number and Percent of Households			
Type of Test	Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
Chemical	457,000 14.0%	17,000 32.9%	0 0.0%	440,000 13.9%
Bacteriological	918,000 28.2%	18,000 35.0%	8,000 17.7%	892,000 28.2%
Both chemical and bacteriological	809,000 24.8%	6,000 12.1%	0 0.0%	803,000 25.4%
Unknown	1,074,000 33.0%	10,000 19.9%	35,000 82.3%	1,028,000 32.5%
Total*	3,257,000 100.0%	51,000 99.9%	43,000 100.0%	3,163,000 100.0%

*Total number of households in which at least one test was done.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

history tended to be more complex and varied in other-rural-area households because there were so many more of them that the chances for diversity were more pronounced than in large or small communities. Even taking this into account, the test history indicated a somewhat more favorable record in households in large communities than elsewhere. That is, there had been at least one test in a larger proportion of large-community households (44.4 percent) than in small-community households (20.2 percent) or in other-rural-area households (37.5 percent). On the other hand, it was likely that more tests had occurred in households in other rural areas than elsewhere. Also, tests had been performed during the most recent decade—1970-79—in a larger proportion of households in other rural areas (68.9 percent, compared to 55.8 percent of households in large rural communities). On the other hand, as an indication of testing currency, in large-community households all tests had been performed after 1960, whereas tests had been performed before 1960 in 9.0 percent of other-rural-area households.

In terms of actual test results, only unacceptable levels of iron presented a problem in large-community households, whereas a total of seven constituents were found in unacceptable concentrations in certain proportions of other-rural-area households. Since chemical tests were not performed in small-community households, there were no results to compare.

INTERMEDIATE SYSTEMS

General reference features of intermediate systems

At the time of the NSA, about 2.2 million rural households in the US were served by 845,000 intermediate systems. Though the NSA defined intermediate systems as those that served from two through fourteen connections, the great bulk of these very small systems—over 91 percent, in fact—consisted of only two or three service connections (see Table VII-36). Another 6.9 percent (59,000) had from four through eight connections. Only 1.9 percent (16,000) had from nine

Table VII-36

Number of Connections for Intermediate Water Systems

	Nation	
Number of Connections	Number of Systems	Percent of Systems
2	645,000	76.4
3	124,000	14.7
4	25,000	3.0
5	12,000	1.4
6	9,000	1.0
7	5,000	0.5
8	8,000	1.0
9	3,000	0.4
10	5,000	0.6
11	2,000	0.3
12	2,000	0.2
13	2,000	0.2
14	2,000	0.2
Total	845,000	99.9

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

through fourteen connections. The average intermediate system had only 2.6 connections, and resembled individual systems in many respects.

Individual systems, of course, did not meter the amount of water used, nor did most intermediate systems (827,000). About 7,000 intermediate systems metered all of their service connections, however. Another 4,000 metered half of their connections, but this finding represented only one system in the NSA sample which was in the process of converting to a metered system. (For 7,000 intermediate systems, it was not known what proportion was metered, if any.)

Since intermediate systems had very few service connections, most of them also had very short distribution lines. In fact, about 80 percent of all intermediate systems (671,000) had only one kilometer or less of service lines. About 44,000 systems had from two through ten kilometers of lines, and 30,000 had eleven through 78 kilometers of lines. One system in the NSA sample, representing about 6,000 systems, had as much as 105 kilometers of service lines; however, this figure included irrigation lines as well as lines supplying water to rural households. For 94,000 intermediate systems, the length of the distribution lines could not be determined.

Intermediate systems tended to resemble individual systems in many other ways, too—in the sources of water they used, for example, as well as in patterns of ownership and system age. The predominant source of water for both intermediate and individual systems was groundwater, which was used by 92.1 percent of intermediate systems and by 93.0 percent of individual systems. About 8 percent of intermediate systems (69,000) used surface water sources. About 3,000 systems (less than 0.5 percent) used precipitation as a source, and a like number purchased their water. Almost all intermediate systems used only one source of water; 8,000 had multiple sources, however, some using combinations of groundwater and surface water and some using both purchased water and precipitation.

In ownership patterns, too, intermediate systems were much like individual systems. Over 90 percent of all intermediate systems were owned by individuals, compared to about 97 percent of individual systems. As one would expect, cooperative arrangements for sharing labor and financial responsibilities of the system were more common among intermediate systems: cooperative ownership was reported by 5.7 percent of intermediate systems, but by only 0.2 percent of individual systems. A few intermediate systems were owned by private firms (1.6 percent, compared to about 1 percent of individual systems). The remaining 2 percent of intermediate systems reported various other forms of ownership, ranging from public ownership to ownership by an Indian tribe (see Table VII-37).

The age of a system may affect the quality, quantity, availability, and cost of the water it supplies. Presumably, when a system undergoes alterations, the purpose is to increase its size or capacity or to improve its performance in terms of the quality or the quantity of water it provides. However, the cost of altering the system may be passed on to the water user. In any event, the date of the last major alteration may have a more direct bearing on the various factors of water supply than the date of initial construction of the system. Thus, the NSA defined the age of a system as the number of years since the system's last major alteration. If the system had not been altered since it was initially built, the age of the system was the number of years since original construction.

Based on the survey results, the median age of intermediate systems was seven years. As seen in Table VII-37, the majority of systems were ten years old or less. About 80 percent had either been constructed or last altered within twenty years of the NSA. Few systems—about 27,000—were more than 50 years old.

Since most intermediate systems had only two or three service connections, their ability to supply water was expected to be quite low relative to that of community systems. Production capacity was gauged in the NSA by two measures —the average amount of water used (produced) daily during the prior year, and the

Table VII-37

Ownership and Age of Intermediate Water Systems

Characteristic	Nation Number of Systems	Percent of Systems
Ownership		
Individual	765,000	90.5
Cooperative	50,000	5.7
Private firm	14,000	1.6
Public	8,000	0.9
Indian tribe	900	0.1
Other	6,000	0.7
Could not be determined	4,000	0.4
Total	845,000	99.9
Age of system (number of years since construction or alteration)		
Less than 1	46,000	5.4
1 - 5	282,000	33.4
6 - 10	174,000	20.5
11 - 20	158,000	18.7
21 - 50	109,000	12.9
More than 50	27,000	3.1
Continuous improvements	2,000	0.2
Could not be determined	48,000	5.7
Total	845,000	99.9

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

system's design capacity, as reported by the respondent for the system. Production capacity has a bearing on a system's pricing structure as well as on the amount of water available each day to the households the system serves. Unfortunately, largely because very few intermediate systems metered their service connections, data for these two measures of production capacity could not be determined for about 80 percent of intermediate systems.

The available data on average daily use and design capacity of intermediate systems are given in Table VII-38. In regard to average daily use, 9.0 percent of intermediate systems had usage levels of from 76 through 500 liters (20 through 132 gallons). No intermediate system reported using less than 76 liters (twenty gallons). About 3 percent reported usage levels of from 501 liters to 1,000 liters, and 6.6 percent reported levels ranging from 1,001 liters to 5,000 liters. Only 10,000 intermediate systems (1.2 percent) reported an average daily use of more than 5,000 liters (1,321 gallons), though a maximum level of 37,900 liters (10,000 gallons) was reported. The median for average daily use was 758 liters, or about 200 gallons.

Figures for maximum daily design capacity were much higher (Table VII-38). Design capacities ranged from 80 liters (21 gallons) to 720,000 liters (190,000 gallons). These estimates closely approximated manufacturers' published ratings for pump capacity. Depending upon a number of key factors which determine pump capacity (including well depth, well size, water tank pressure, and type of pump), published ratings ranged from 90 liters to 715,000 liters, very close to NSA estimates.[16] The median for maximum daily design capacity was 44,000 liters (11,609 gallons), nearly 60 times the median daily usage level. (Again, caution is advised when interpreting data on production capacity, since about 80 percent of systems could not supply information.)

Table VII-38

Average Daily Use and Maximum Daily Design Capacity of Intermediate Systems

Quantity in Liters	Approximate Quantity in Gallons	Nation Number of Systems	Nation Percent of Systems
Average Daily Use (during year preceding NSA)			
1 - 500	1 - 132	76,000	9.0
501 - 1,000	133 - 264	26,000	3.1
1,001 - 5,000	265 - 1,320	55,000	6.6
More than 5,000	More than 1,321	10,000	1.2
Could not be determined		675,000	80.1
Total		845,000	100.0
Maximum Daily Design Capacity			
1 - 25,000	1 - 6,604	61,000	7.2
25,001 - 50,000	6,605 - 13,208	32,000	3.8
50,001 - 100,000	13,209 - 26,417	28,000	3.3
100,001 - 500,000	26,418 - 132,086	46,000	5.4
More than 500,000	More than 132,086	12,000	1.5
Could not be determined		665,000	78.7
Total		845,000	99.9

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

External engineering features of intermediate systems

As was done in the previous section on individual systems, the external engineering features of intermediate systems (those features which are usually located outside the household) are categorized here in relation to the type of supply and the source of the water. Presented first are the external engineering features of wells and springs, both of which are dependent on groundwater sources; next, the external features of surface water supplies are considered. The relevant features of cisterns are described only as a special case, since the NSA sample included only one intermediate system using precipitation as a water source.

Again, as with individual systems, the external engineering features treated in the NSA were primarily related to sanitary and pollution control measures. However, some features also were related to supply quantity or cost. The information was collected in part by questioning of household respondents, and in part by inspection of the premises by interviewers.

Intermediate system wells

Of the 845,000 intermediate systems serving rural US households, about 88 percent (745,000) relied on wells. This finding was one of many similarities between individual and intermediate systems (90 percent of individual systems used wells).

— Sites of intermediate system wellheads

The siting of wellheads is one of several physical features that influence water quality. (Others are the method of construction, the depth of the well, and well grouting—cementing the space between the well and the surrounding soil.) Possible configurations range from wells which are completely exposed to environmental conditions to those which are completely protected. In the NSA, the largest proportion of rural intermediate system wellheads, an estimated 54 percent, terminated above ground but were protected by some structure such as a pumphouse (see Table VII-39). On the other hand, 14.1 percent of wellheads terminated above ground and were uncovered.

A total of 11.6 percent of intermediate wells (86,000) were located in pits, approximately half with watertight covers and half without. Since water may accumulate in well pits from leaky covers or from leaky pipes, pits are not generally considered an adequate form of wellhead protection. However, some improvement can be gained by installing a drain to remove accumulated water. Though not shown in Table VII-39, 48.8 percent of the 86,000 intermediate wells in pits had no drain, while 46.1 percent drained to open ground and 5.1 percent led to a drainline or sewer line.

About 12 percent of intermediate wellheads were buried, and about 3 percent were located inside the dwelling unit. Miscellaneous other configurations were used in 1.3 percent of intermediate wells, and arrangements could not be identified for 4.3 percent.

—Construction of intermediate system wells

As shown in Table VII-40, an estimated 65 percent of all intermediate wells were drilled. Sanitary engineers consider drilled wells the most satisfactory type for providing water of good quality, but drilled wells are not necessarily entirely free from contamination, since contamination is also related to other physical features such as the depth and age of the well and the presence of well grouting.

Compared to drilled wells, a much smaller proportion of intermediate wells were bored (8.9 percent) or dug (8.3 percent). Bored and dug wells generally are unprotected from contamination. In particular, dug wells tend to be shallow and lack adequate covering, allowing contamination to enter either at the top of the well or below ground level.

Table VII-39

Wellhead Arrangements for Intermediate System Wells

Classification	Nation Number of Systems	Percent of Systems
Terminated above ground		
Protected by shed, roof, or other structure	400,000	53.7
Uncovered	105,000	14.1
Subtotal	505,000	67.8
Situated in well pit		
Pit without watertight cover	45,000	6.1
Pit with watertight cover	41,000	5.5
Subtotal	86,000	11.6
Buried	89,000	12.0
Situated in household	22,000	2.9
Miscellaneous arrangements	10,000	1.3
Arrangements could not be determined	32,000	4.3
Total	745,000	99.9

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-40

Construction of Intermediate System Wells

Type of Construction	Nation Number of Systems	 Percent of Systems
Drilled	481,000	64.5
Bored	65,000	8.9
Dug	62,000	8.3
Driven	22,000	3.0
Jetted	16,000	2.1
Could not be determined	99,000	13.3
Total	745,000	100.1

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

A few intermediate wells (3.0 percent) were driven (by pounding a pre-assembled pipe system into the ground), and 2.1 percent were jetted (by forcing a stream of high pressure water down through a center pipe). The type of construction could not be determined for about 13 percent of intermediate wells.

—Age of intermediate system wells

The age of a well was defined in the NSA as the number of years since it was constructed or since it was last altered. NSA results showed that intermediate wells tended to be older than individual wells. (The median age of intermediate wells was about nine years, compared to about eight years for individual wells.) As shown in Table VII-41, nearly one out of three intermediate wells was five years old or less. Altogether, about 66 percent of intermediate wells were twenty years old or less. Wells that are more than twenty years old are more subject to contamination, according to a 1971 EPA survey in Tennessee,[17] and the NSA found that about 20 percent of intermediate wells (147,000) were more than twenty years old. The age of 14.4 percent of intermediate wells could not be determined.

— Depth of intermediate system wells

The depth of well shafts has been closely linked to water quality. In general, the deeper the well, the greater the likelihood that suspended particles including microorganisms will be filtered out as water seeps downward through overlying material to the aquifer. Of course, the extent of filtration is dependent upon the character of overlying material as well as its thickness. One recommendation for protection against contamination is that water should percolate through at least ten feet of earth.[18] Only 1.5 percent of intermediate wells were deficient according to this criterion, being only three meters deep or less (see Table VII-42). The median depth of intermediate wells was estimated to be about 28 meters (92

Table VII-41

Age of Intermediate System Wells

Age (Number of Years Since Construction or Alteration)	Nation	
	Number of Systems	Percent of Systems
5 or less	236,000	31.7
6 - 10	103,000	13.8
11 - 15	94,000	12.6
16 - 20	58,000	7.8
21 - 50	118,000	15.8
More than 50 years	29,000	3.9
Could not be determined	107,000	14.4
Total	745,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-42

Depth of Intermediate System Wells

Depth in Meters	Approximate Depth in Feet	Nation Number of Systems	Percent of Systems
3 or less	Less than 10	11,000	1.5
4 - 9	11 - 30	64,000	8.5
10 - 15	31 - 50	45,000	6.0
16 - 21	51 - 70	88,000	11.8
22 - 30	71 - 100	112,000	15.1
31 - 61	101 - 200	194,000	26.0
62 - 91	201 - 300	67,000	9.0
92 - 122	301 - 400	26,000	3.6
123 - 152	401 - 500	20,000	2.7
153 - 379	501 - 1,243	8,000	1.1
Could not be determined		110,000	14.7
Total		745,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

feet), about the same as the median depth of individual wells (approximately 27 meters).

— Casing diameter for intermediate system wells

NSA respondents were asked to estimate the diameter of the well casing (the distance inside from one wall to another). Survey results indicated the prevalence of standard even-size casings. (Casing diameter was measured only for wells which were drilled, driven, bored, or jetted—a total of 683,000 intermediate wells). Two-inch casing (5.1 centimeters) was found at 7.5 percent of the measured intermediate wells; four-inch casing (10.2 centimeters) was found in about 14 percent; six-inch casing (15.2 centimeters) was found in 30 percent; and eight-inch casing (20.3 centimeters) was found in 10 percent. Few intermediate system wells (4.2 percent) had casings with diameters larger than eight inches (20.3 centimeters). About 14 percent had uneven-sized casings. Information could not be obtained for 20.2 percent of intermediate system wells.

— Grouting in intermediate system wells

Grouting a well—sealing the space between the well casing and the soil around it—provides important protection against contamination. Of the 683,000 drilled, driven, bored, or jetted intermediate system wells, almost 40 percent were not grouted while 35 percent were. It could not be determined whether 25 percent of intermediate wells were grouted or not.

— Wellhead sealing against pollutants

Arrangements for protecting wells from external contamination were checked by direct inspection. NSA interviewers were specially trained by sanitary engineers to make the inspection (see Appendix C). Three issues were addressed: (1) acceptability of the well cover for preventing the entry of solid or liquid pollutants (its general acceptability), (2) the ability of the well cover to keep runoff from entering the inside of the well casing (splashproof or not), and (3) whether the source was adequately protected or not.

Acceptability of the well cover was assessed on the basis of the wellhead's general condition rather than on the basis of compliance with any standard wellhead design, since a wide variety of wellhead configurations and sealing arrangements were encountered in the NSA survey. For example, wide-diameter dug wells were sometimes covered by large reinforced concrete slabs, while wells with pitless adapter access pipes might be fitted with smaller tip-up metal caps. In any case, the cover was judged unacceptable if it had an opening more than 1/16th inch wide, or if it would allow surface runoff or small animals to enter the well. The cover was also judged to be unacceptable if the well had a pump which had to be primed more than once a month, since priming could introduce pollutants. NSA results showed that well covers were acceptable in more than three out of four intermediate systems (568,000 systems). However, for approximately 123,000 intermediate systems, well covers were unacceptable. For the remaining 54,000 systems, the acceptability of the well cover could not be determined (see Table VII-43).

A splashproof well cover was one which was watertight and not exposed to flooding or surface runoff. Data on splashproof covers were identical to data on the general acceptability of well covers, as seen in Table VII-43. That is, the majority of intermediate wells across the nation had covers that were splashproof, but 123,000 did not.

Source protection was assessed in two ways. First, the overall condition of the immediate area was checked to see if it was free from debris and extraneous objects unrelated to the water supply. Second, if a well were situated so that surface water could drain directly into it, then surface drainage was not controlled, and the wellhead area was judged to be inadequately maintained. (A precaution

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Table VII-43

Adequacy of Wellhead Sealing and Source Protection of Intermediate System Wells

Characteristic	Nation Number of Systems	 Percent of Systems
Cover (general acceptability)		
Acceptable	568,000	76.3
Unacceptable	123,000	16.5
Could not be determined	54,000	7.2
Total	745,000	100.0
Cover (splashproof or not)		
Splashproof	567,000	76.2
Not splashproof	123,000	16.5
Could not be determined	54,000	7.2
Total	745,000	99.9
Source protection		
Adequately protected	572,000	76.8
Not adequately protected	120,000	16.2
Could not be determined	53,000	7.1
Total	745,000	100.1
Combined evaluation		
Acceptable on all three factors	497,000	66.8
Unacceptable on one factor	48,000	6.4
Unacceptable on two factors	47,000	6.4
Unacceptable on all three factors	73,000	9.8
Could not be determined	79,000	10.7
Total	745,000	100.1

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

might be to mound up earth surrounding the wellhead so that the ground sloped away from the well in all directions.) NSA results showed that over 75 percent of intermediate system wells (572,000) were adequately protected; 16.2 percent, or 120,000, were not. Necessary information could not be obtained for the remaining 53,000 intermediate system wells.

Data on these three separate factors were tabulated together to provide a more accurate view of the overall condition of intermediate-system wellheads. The combined evaluation indicated there were more wells with unacceptable conditions than might be inferred from the data on the three separate factors.

For instance, according to the separate tabulations, about three-quarters of all intermediate wells were acceptable on each factor. However, the combined evaluation showed that only two-thirds (about 497,000 wells) were acceptable with respect to all three factors. By the same token, fewer wells were unacceptable on all three factors than might be inferred from the separate tabulations—9.8 percent, compared to about 16 percent unacceptable with respect to each separate condition. About 6.4 percent of intermediate wells (about 48,000) were judged acceptable on two of the three conditions, and a like number were acceptable on only one condition. In all, 22.6 percent of intermediate wells (168,000) were unacceptable on at least one factor. (A combined evaluation could not be made for 10.7 percent of intermediate wells.)

— Distance to potential pollution sources

The EPA advises that a distance of at least 50 feet (approximately sixteen meters) is needed to protect properly constructed wells from sources of potential pollution.[19] (No safe distance can be cited for poorly constructed wells.) Of course, this distance is a very rough estimate, since geology is a key factor and assessments of geological formations were beyond the scope of the NSA.

In describing situations of potential contamination, the NSA adapted the EPA guideline. Among intermediate system wells, the most visible type of pollution source was sewage disposal which, for about 16 percent of the 745,000 intermediate wells, was located less than sixteen meters from the center of the wellhead (see Table VII-44). Oil or gasoline pollution, although somewhat less visible, was detected as a potential threat to more than 100,000 intermediate wells (14.4 percent). Other types of possible pollution sources each were detected at less than 10 percent of intermediate wells.

When potential pollution sources were detected, median distances between the wellhead and the pollution source exceeded sixteen meters, except in the cases of oil or gasoline pollution, industrial waste, and highway salt. However, both industrial waste and highway salt were found only infrequently, which suggests that they were detected only when the potential pollution source was very close to the supply. Although the median distance to sources of agricultural pollution was relatively large (roughly 25 meters), the problem may be more severe than indicated by the survey results, considering the difficulty of detecting such sources.

— Access to well equipment (pitless adapter, buried seal)

As discussed earlier, wells should be accessible at the top for inspection, servicing, and testing. With this criterion in mind, pitless adapters or pitless units (no attempt was made to differentiate between the two in the NSA) were preferred over buried seals as protection against contamination. (A pitless adapter eliminates the need for a well pit, thereby removing potential pollution hazards.) The adapter is installed below the frost line, dividing the water pipe into two sections. The section which extends to the house is permanently sealed; the other section, attached to the pump or pump intake, can be removed for servicing without

Table VII-44

Distance Between Intermediate System Wells and Potential Pollution Sources

	Nation		
Type of Pollution Source	Percent of Wells Where No Potential Pollution Source Was Determined*	Percent of Wells Within 16 m of Potential Pollution Source*	Median Distance from Potential Pollution Source**
Sewage disposal system	22.7	16.3	29.8 m (576,000)
Oil or gasoline tank	74.1	14.4	15.0 m (193,000)
Animal waste	80.1	9.3	17.7 m (148,000)
Agricultural fertilizer or runoff	84.0	6.2	25.2 m (119,000)
Surface water contamination (such as pond, lake, or river which might flood into well)	89.4	4.5	29.6 m (79,000)
Highway salt	97.4	1.6	11.6 m (19,000)
Industrial waste	98.3	1.0	1.5 m (13,000)
Other contamination	97.4	2.5	0.7 m (19,000)

*Base: All intermediate system wells (745,000).

**Median distances were calculated from measurements at wells where potential pollution sources of each type were noted; bases given in parentheses.

disturbing the watertight casing below. In the NSA survey, pitless adapters were installed in 122,000 intermediate system wells (only 16.4 percent of the total).

As explained elsewhere in this chapter, the buried seal is undesirable for a number of reasons: (1) it discourages periodic inspection and preventive maintenance; (2) it increases the cost of servicing; and (3) it increases the likelihood of damaging and polluting the well, since excavation is required for servicing. The NSA showed that 13.8 percent of all intermediate system wells (103,000) had a buried seal. Furthermore, about 57 percent of intermediate wells had neither pitless adapter nor buried seal (this was not necessarily undesirable, depending upon other configurations for protecting against pollutants). Finally, pertinent information could not be obtained for nearly 13 percent of intermediate system wells.

Intermediate system springs

Of the 845,000 intermediate systems across the nation, only 81,000 were supplied by springs. (As discussed previously, well supplies predominated for both individual and intermediate systems.) Springs—also a groundwater source—were the next most prevalent type of supply among intermediate systems, while surface water sources and cisterns were used least often among intermediate systems.

With regard to springs, pollution was the key issue under investigation. Three aspects of spring systems were studied: (1) the adequacy of cover protection for the spring reservoir, (2) the maintenance of the area surrounding the spring reservoir, and (3) the proximity to specific pollution sources.

— Intrusion protection for intermediate system springs

If a spring has some type of underground storage reservoir, EPA recommends a removable cover for cleaning—but a cover which can keep out water, solid pollutants, and animals.[20] For springs which are tapped at ground level, a structure similar to a watertight wellhouse would provide adequate protection for the spring reservoir.

NSA results showed that three of every four intermediate system springs —a total of 61,000—had either an unacceptable cover or no cover at all. In addition, two of every three intermediate springs (roughly 53,000) were not adequately protected. That is, either diversion ditches had not been constructed to allow surface water to drain away from the spring, or the spring area was not fenced off, or the general appearance of the area surrounding the spring reservoir was poor.

— Distance to potential pollution sources for intermediate system springs

Safe distances from a spring to sources of contamination are difficult to establish, since springs are particularly susceptible to pollution. Further risk was evident from the NSA finding that a majority of springs were not adequately covered or protected. Recommendations for establishing safe distances to potential pollution sources have ranged from 25 feet for human and animal contamination to no distance being safe for any potential pollution source. In the absence of any specific distance being generally agreed upon by sanitary experts, an arbitrary distance was chosen as a reference point—30 meters, or about twice the recommended minimum distance between wells and possible pollution sources.

As shown in Table VII-45, the median distance between potential sources of pollution and springs was greater than 30 meters for many types of pollution (sewage disposal systems, fuel tanks, fertilizer runoff, and highway salt). On the negative side, however, animal waste and surface water contamination were often very close, the median distance being less than ten meters from the spring. The finding that potential surface water contamination generally occurred adjacent to the spring was not unexpected, since springs often rise to the ground surface, where they are subject to all types of contamination.

Table VII-45

Distance Between Intermediate System Springs and Potential Pollution Sources

	Nation		
Type of Pollution Source	Percent of Springs Where No Potential Pollution Source Was Determined*	Percent of Springs Within 30 m of Potential Pollution Source*	Median Distance from Potential Pollution Source**
Surface water contamination (such as pond, lake, or river which might flood into spring)	73.1	22.9	9.0 m (22,000)
Animal waste	77.6	12.0	3.2 m (18,000)
Sewage disposal system	28.0	6.1	90.8 m (59,000)
Agricultural fertilizer or runoff	91.9	0.0	87.5 m (7,000)
Oil or gasoline tank	92.6	0.0	171.9 m (6,000)
Highway salt	98.0	0.0	300.0 m (2,000)
Other contamination	91.2	8.8	3.0 m (7,000)

*Base: All intermediate system springs (81,000).

**Median distances were calculated from measurements at springs where potential pollution sources of each type were noted; bases given in parentheses.

The most striking finding with regard to springs and potential pollution sources was that distance measurements were most often not made, which suggests that either there were no potential pollution sources in the vicinity or that their presence was difficult to determine. Similarly, measurements often were not made for wells, so Tables VII-44 and VII-45 can be compared. Generally speaking, NSA data indicated a greater degree of security for intermediate springs than for intermediate wells. For example, the proportion of springs within the reference-point distance from potential sources of pollution was usually much smaller than the corresponding proportion of wells, except for surface water contamination and animal waste.

Intermediate surface water systems

Surface water sources (lakes, ponds, and streams) supplied very few intermediate systems—about 15,000 of the 845,000 intermediate systems in the US. (Earlier it was reported that 69,000 intermediate systems used surface water sources. The discrepancy in the two estimates occurred because information relating to the type of supply was collected from household respondents, while information on the source of water used by the system was obtained from system owners or managers. The two pieces of information did not always correspond.)

Since lakes, ponds, and streams are inherently open to the environment, all 15,000 intermediate systems using surface water sources were judged to have unacceptable intrusion protection. Two other conditions were also evaluated, however—the adequacy of source protection and the promixity to potential pollution sources. Surface water sources were considered adequately protected against pollution if they were fenced, surrounded by a well-kept grassy area, and kept free of weeds and floating debris. An estimated 63 percent of all intermediate surface water systems were judged to be adequately protected; about

23 percent were not adequately protected. The adequacy of source protection could not be determined for the remaining 14 percent.

Since possibilities are rife for contamination of surface water supplies, safe distances to potential pollution sources are a critical consideration. They are difficult to estimate, however, since so many factors are involved. Consequently, data are presented on the distance of intermediate surface water supplies to potential pollution sources without an attempt to estimate safe distances. Findings are summarized in Table VII-46. In many cases (as was also true for wells and springs), no distances could be determined. And again, it is not known whether this reflected a true absence of potential pollution sources or the difficulty in observing some types of pollution sources.

Special consideration of intermediate system cisterns

Although the NSA found an estimated 133,000 individual system cisterns in the US, intermediate system cisterns were rare. In fact, the NSA encountered only one intermediate system using a cistern. Since the case is unique as well as interesting, it is described in detail here, though population estimates cannot be made (cistern supplies served less than 0.5 percent of all intermediate systems).

The one intermediate cistern system encountered in the NSA was located in the Northeast and served three rural households. When the system was originally constructed in 1950, the basic unit included two storage reservoirs (cisterns), one electric pump, and service lines. No modifications had been made to the system. The cost of the basic unit in 1950 was approximately $1,000.

The system was not able to provide a sufficient amount of water to the three households it served. Indeed, the system supplemented the cistern supply by purchasing nearly half of its water from a nearby city. With regard to structural characteristics, the system was generally unprotected from potential pollution sources. It had no first-water diverter and no cleaning drain. The system did have

Table VII-46

Distance Between Intermediate Surface Water Systems and Potential Pollution Sources

Type of Pollution Source	Nation: Percent of Surface Water Systems Where No Potential Pollution Source Was Determined*	Nation: Median Distance From Potential Pollution Source**
Surface water contamination (source itself)	26.8	88.3 m (11,000)
Sewage disposal system	45.1	47.9 m (8,000)
Agricultural fertilizer or runoff	62.5	3.0 m (6,000)
Oil or gasoline tank	93.6	38.0 m (1,000)
Animal waste	93.6	0.0 m (1,000)
Other contamination	85.5	0.0 m (2,000)

*Base: All intermediate surface water systems (15,000).

**Median distances were calculated from measurements at surface water systems where potential pollution sources of each type were noted; bases given in parentheses.

a rooftop catchment area, however, rather than a more easily contaminated surface catchment area.

The NSA respondent being served by this intermediate cistern system identified a number of other problems besides the insufficient quantity of water provided by the system. The respondent reported that the water was usually slightly cloudy and slightly colored, and that it usually contained some sediment throughout the year. In addition, the system's pressure was inadequate. All in all, the respondent disliked the cistern supply.

General system considerations for all intermediate systems

The presentation of intermediate systems began with general characteristics common to all systems—size, metering, source, ownership, age, daily water usage, and maximum daily design capacity. Other general considerations of all intermediate systems ranged from water distribution and treatment devices to the quality of service as assessed through reliability and laboratory water quality measurements. These latter considerations are treated in this section. The two sections describing general system attributes were separated because the intervening material—the engineering aspects of wells, springs, and surface water supplies—provided a detailed background for the following discussion.

Methods for distribution of water in intermediate systems

Distribution systems, composed of physical structures for propelling and conveying water, link supplies with rural households. The way in which water is distributed is important because it is one key factor in determining adequacy of service.

The NSA found that most intermediate systems (about 91 percent) distributed water by means of electric pumps. A small number of systems (nearly 50,000) relied upon gravity flow, which is usually considered an inefficient means of transport. Very few systems used artesian pressure (about 3,000). Finally, the means of propulsion could not be determined for an estimated 2.8 percent of the 345,000 intermediate systems in the US. (Of course, by definition, hand-carrying and hauling were not methods of transport used by intermediate systems.)

Water distribution and treatment devices in intermediate systems

The basic components of any water supply system are a water supply, service lines, and a means for propelling water through the distribution system. Data presented here pertain only to those 484,000 intermediate systems which had never undergone major alterations and which could supply the necessary information.

Necessarily, all intermediate systems had service lines as part of original system equipment. Most of the 484,000 systems also installed pumps at the time of system construction, although a few (74,000) relied on other methods of propulsion. Pressure tanks were installed at the time of construction in 28.0 percent of the systems, and storage tanks were installed at the time of construction in 13.3 percent. Less than 5 percent had installed either treatment equipment or reservoirs as part of original system equipment.

With regard to water treatment by intermediate systems, information was obtained in terms of both the treatment processes and the specific items of treatment equipment that were operating at the time of the NSA survey. (This information was obtained for all intermediate systems, whether or not they had undergone alterations.) Besides gaining additional data on the reliability of various pieces of equipment, this approach was needed because there was not always a one-to-one correspondence between treatment process and treatment device. For example, treatment devices such as "activated carbon filters" and "oxidation filters" both are associated with a process known as "filtration." Discovering that the system performs filtration is useful, but discovering as well the particular device being used is even more helpful.

As shown in Table VII-47, water treatment was relatively rare among intermediate systems. Softening was the most common treatment, but occurred in only 51,000, or 6.0 percent, of all intermediate systems. (Softening devices were functioning in about 47,000 systems.) Activated carbon filters were installed and operating in 8,000 intermediate systems; other types of filters were in use at 15,000 systems. Although 24,000 intermediate systems chlorinated their water, only about 15,000 had functioning chlorinators at the time of the NSA (some systems may have used liquid chlorine dispensers, which were not considered chlorinators in the NSA).

Although NSA data on water distribution equipment—pumps, pressure tanks, and storage tanks—were restricted to the 484,000 systems which had not undergone alterations since original construction, some comparisons with individual system water distribution equipment can be made. Equal proportions of individual and intermediate systems (about 92 percent) used pumps for water transmission. Storage tanks, on the other hand, were twice as common among intermediate systems, probably because of the greater demand for water. Interestingly, pressure tanks were used in 89.2 percent of individual systems but in only 28.0 percent of intermediate systems. Since the data pertained to systems which had not been modified since initial construction (about 57 percent of intermediate systems), the data may reflect a less well developed condition among these systems. (However, even if all systems which had undergone modifications had pressure tanks, the combined percentage would be only 71.0 percent, which is still significantly lower than the percentage of individual systems with pressure tanks.)

A similar comparison was made for treatment at individual and intermediate systems. Where direct comparisons could be made—between activated carbon or anthracite filters, softeners, and chlorinators—individual systems out-

Table VII-47

Treatment Processes and Treatment Devices in Intermediate Systems

Characteristic	Nation Number of Systems*	 Percent of Systems**
Treatment Processes		
Filtration	24,000	2.9
Softening	51,000	6.0
Chlorination	24,000	2.8
Other treatment	6,000	0.7
None	759,000	89.9
Treatment Devices in Operation		
Activated carbon or anthracite filter	8,000	0.9
Softener	47,000	5.6
Chlorinator	15,000	1.7
Miscellaneous filter	15,000	1.8
None	763,000	90.3

*Table reports systems having at least one treatment process or device; some systems may have had more than one.

**Base: All intermediate systems in rural US (845,000).

numbered intermediate systems in the use of one: softeners were far more common among individual systems (17.6 percent, compared to 5.6 percent of intermediate systems). Chlorinators and activated carbon filters were used by less than 2 percent of either group. Moreover, individual systems had a wide variety of treatment equipment, including phosphate feeders and settling tanks, while such equipment was never reported among intermediate systems.

In summary, water distribution and treatment devices appeared to be more extensive and more elaborate for individual systems than for intermediate systems.

Intermediate system operators

In order for a system to perform effectively, it must have a sufficient number of trained personnel available to operate and repair its equipment. Among intermediate systems, paid, trained personnel were uncommon. Specifically, nearly 50 percent of intermediate systems had a single operator; about 35 percent reported having no operators at all. An estimated 11 percent had two operators. Considering the size of intermediate systems (two through fourteen connections), two operators were probably not essential for efficient system operation, but may have represented a cooperative arrangement for maintenance. Some cooperative arrangement also probably existed at the 28,000 intermediate systems having three, four, or five operators (see Table VII-48).

Of the 537,000 intermediate systems with operators, only 7,000 had operators who were paid, full-time employees. Most (84.6 percent) had at least one volunteer operator, who received no payment for the work. Where the work was not conducted by volunteers, it was most often undertaken by paid, part-time operators who worked 30 hours or less a week.

Since the majority of intermediate systems used volunteer operators, special training in the operation of the system's equipment also was rare. (Special training was defined as state-conducted programs, equipment manufacturers'

Table VII-48

Number and Work Status of Operators of Intermediate Systems

Characteristic	Nation Number of Systems	Percent of Systems
Number of Operators		
0	299,000	35.4
1	412,000	48.8
2	97,000	11.4
3 - 5	28,000	3.3
Could not be determined	9,000	1.0
Total	845,000	99.9
Status of Operators*		
Volunteer	462,000	84.6
Paid part-time	55,000	10.0
Paid full-time	7,000	1.3
Could not be determined	25,000	4.6
Total	546,000	

*Percentages for status of operators are based on the total number of systems which had operators, about 546,000; percentages do not add to 100 percent because, for example, one system may use both full-time and part-time operators.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

workshops, or programs offered through Cooperative Extension. It did not include on-the-job training.) Indeed, fully 96.0 percent of systems with operators used persons who had received no special training. Only about 3 percent of the intermediate systems with operators (24,000) had operators with special training. At most of these 24,000 systems, all operators had received special training; at a few, half of the operators had received special training.

Intermediate systems were reported to require very little time for operation and maintenance. About 83 percent of all intermediate systems reported that the amount of time involved was less than one man-day per month (less than eight hours), and 6 percent reported that a single man-day was required. Very few systems (less than 1 percent) required two or more man-days of work, although the maximum reported was 60 man-days, or 480 hours (temporary, full-time work on the part of all system operators may have been necessary for a major alteration that was taking place). For 8.7 percent of all intermediate systems, the time required for operation and maintenance could not be determined.

System performance

To satisfy the demands of several households, intermediate systems had to provide a sufficient volume of water on a continuous basis. This meant that equipment had to be functioning at all times and that there should never be either a partial or complete loss of the supply. In the NSA, then, one measure of system performance was the number of breakdowns that the system had experienced during the year prior to the survey. Supplementary information also was collected regarding the reasons for the breakdowns and a count of those which resulted in a loss of service to water users. Secondly, system performance was evaluated in terms of the ease or difficulty in acquiring water from the source. The reasons for such difficulties also were tabulated.

In the NSA, system breakdowns were defined as any interruption of the system's capability to acquire, treat, or deliver water. At three of every four intermediate systems, no breakdowns had occurred during the year prior to the NSA (see Table VII-49). An estimated 217,000 systems did report breakdowns, but about two-thirds of these systems (139,000) had experienced only one, and 47,000 had experienced two. More frequent breakdowns were rare, but a few systems had more than 95 (the coding limit in the NSA). Moreover, nearly all of the system breakdowns (192,000) were severe; that is, they resulted in a loss of service to water users. The maximum number of severe breakdowns was smaller than the total number of system breakdowns, however—fifteen, compared to 96 or more.

Sometimes, service interruptions can be intentional—while making improvements to physical facilities, for example. Among intermediate systems, however, all reported service interruptions were caused by unplanned events (see Table VII-49). Of the 217,000 intermediate systems reporting breakdowns, 96,000 reported that at least one breakdown was caused by pump malfunctions. (With pump malfunctions, these systems were probably not operational, since small systems rarely had auxiliary pumps.) About the same number of systems (89,000) said breakdowns had been caused by ruptured lines. Power failure caused breakdowns at 18,000 intermediate systems. Flooding, which can contaminate a system's water or damage its equipment, caused breakdowns at 2,000 intermediate systems.

In terms of the second criterion used to measure system performance, only 62,000 of the 845,000 intermediate systems across the nation reported having difficulty in obtaining water from ground or surface sources. Since the source for 92 percent of intermediate systems was groundwater, it was not surprising that intermediate systems predominantly reported difficulties in obtaining water from a groundwater source (47,000 systems, or 75.9 percent of intermediate systems which had experienced difficulties in obtaining water from any source). About 23

Table VII-49

Frequency and Reasons for Breakdowns in Intermediate Systems

Characteristic	Nation Number of Systems	Nation Percent of Systems
Number of Breakdowns During Previous Year		
0	628,000	74.3
1	139,000	16.4
2	47,000	5.6
3	18,000	2.2
4	7,000	0.8
5 or more	6,000	0.7
Total	845,000	100.0
Reasons for Breakdowns		
Pump malfunction	96,000	44.2*
Ruptured lines	89,000	41.1
Power failure	18,000	8.2
Drought	2,000	1.1
Flooding	2,000	0.8
Vandalism	2,000	0.8
Treatment failure	1,000	0.5
Other reasons	23,000	10.5
Total Systems with Breakdowns	217,000	

*Percentages for reasons for breakdowns are based on the total number of systems which had breakdowns, about 217,000; percentages exceed 100 percent because a system may have given multiple reasons in the event of two or more breakdowns.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

percent, or 14,000 systems, had experienced difficulties in obtaining water from a surface water source. While 3,000 systems relied on purchased water as a source, none of these systems reported problems in acquiring water.

Viewing the data differently, only 79.7 percent of intermediate systems using surface water sources reported no difficulties in acquiring water, compared with 94.0 percent of intermediate systems using groundwater (see Table VII-50). Systems which had experienced problems with surface water sources reported four types of problems fairly evenly, as shown in Table VII-50: contamination, weather problems, equipment breakdowns, and an insufficient quantity of water.

When systems using groundwater reported difficulties in acquiring water from the source, they most frequently mentioned equipment breakdowns (26,000, or 3.3 percent of intermediate systems). In fact, this problem was reported twice as often as any other (see Table VII-50). Contamination was notably absent as a cause of problems for intermediate systems using groundwater sources.

Intermediate system water test history

Careful monitoring of water quality is essential to ensure safe water for human consumption and use. Testing is particularly important at the supply system, because it is there that the problems can be more easily remedied. Water quality tests could be conducted at the household and the required treatment installations made there, but such alterations would not benefit other households connected to the same system.

The NSA gathered data from intermediate systems on both bacteriological and chemical water quality tests. It ascertained the frequency of bacteriological tests and where the tests were performed. In addition, the results of the most recent chemical water quality test were requested. (The date of the chemical test gave a rough indication of the frequency of such tests, but it did not necessarily reflect the last time the test was performed).

Table VII-50

Difficulties in Acquiring Water for Intermediate Systems Using Groundwater and Surface Water

Difficulties	Nation Number of Systems	Nation Percent of Systems*
Groundwater		
No difficulties	731,000	94.0
Equipment breakdowns	26,000	3.3
Insufficient quantity	13,000	1.7
Weather problems	9,000	1.2
Loss of a supply	3,000	0.4
Total	778,000	
Surface water		
No difficulties	55,000	79.7
Equipment breakdowns	3,000	4.3
Insufficient quantity	3,000	4.3
Weather problems	5,000	7.2
Contamination	6,000	8.7
Total	69,000	

*Percentages are based on the number of systems using each source; percentages exceed 100 percent since multiple difficulties were sometimes reported.

— Bacteriological water quality tests

Nearly three of every four intermediate systems (620,000 systems) had never performed bacteriological tests. Furthermore, although 189,000 intermediate systems (22.4 percent) reported that bacteriological tests had been performed, the overwhelming finding was that testing was done infrequently or irregularly. (At about 36,000 systems, it was not known whether bacteriological tests were ever performed.) As shown in Table VII-51, only about 5 percent of the systems that tested for bacteriological content did so at least once every six months; about 4 percent performed tests at least once every three months. Monthly or more frequent testing was reported by only 4.5 percent (8,000 intermediate systems). A large proportion of systems (about 10 percent) could not provide information on the frequency of bacteriological testing, implying either that testing was not done on a regular basis or that the system respondent was not knowledgeable about the system's testing practices.

As to what organizations conducted bacteriological tests for intermediate systems, the NSA found that more than 50 percent of systems had the tests conducted by either county or state public health departments (see Table VII-51). Private laboratories performed the tests for 13.0 percent of systems, and state environmental departments conducted them for about 12 percent. As would be expected, hardly any intermediate systems were equipped to perform their own bacteriological tests.

The NSA tried to assess past bacteriological content of intermediate systems' water by finding out what proportion of tests conducted within one year of the NSA met the relevant state, local, or federal regulations. The NSA limited this assessment to tests conducted in the past year, or to the last twelve tests within that year, in order to get an estimate of current conditions at the system.

As noted earlier in this section, only 189,000 intermediate systems had ever performed bacteriological tests and most of these conducted the tests

Table VII-51

Frequency of Bacteriological Water Quality Tests Among Intermediate Systems, and Organizations Conducting the Tests

Characteristic	Nation Number of Systems	Nation Percent of Systems
Frequency of tests		
Not performed regularly	30,000	16.1
Once a year or less often	115,000	60.7
At least once every six months	9,000	4.8
At least once every three months	7,000	3.8
At least once every month	6,000	3.3
At least once a week	2,000	1.2
Could not be determined	19,000	10.1
Total	189,000	100.0
Organizations conducting tests		
Public health department	98,000	51.8
Private laboratory	25,000	13.0
State environmental department	23,000	12.2
Federal laboratory	7,000	3.6
Hospital laboratory	4,000	1.9
System laboratory and either public health department or state environmental department	1,000	0.6
System laboratory	300	0.2
Other	12,000	6.4
Could not be determined	20,000	10.3
*Total	189,000	100.0

*Table includes only those intermediate systems which reported conducting bacteriological water quality tests (22.4 percent of all intermediate systems).

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

infrequently or irregularly. In short, only 131,000 systems had performed tests within a year of the NSA and could provide test results. Of these, 91.1 percent reported acceptable bacteriological content in all tests performed during the year, and 2.8 percent reported acceptable results in over 90 percent of the tests conducted. However, about 8,000 systems reported that at least 50 percent of the tests had failed.

— Chemical and physical water quality tests

While 22.4 percent of intermediate systems had conducted bacteriological water quality tests, only 9.7 percent, or 82,000, reported that chemical and physical tests had been performed and could also provide test results. (At 62,000 systems, it was not known whether chemical tests had been performed or, if they had, what the results were.)

Well over half of the chemical tests for which intermediate systems were able to provide results were conducted in 1976 or more recently (see Table VII-52). The earliest test for which results were obtained was conducted in 1955, which may have been the time of original construction of the system. Results of system tests are not presented because a maximum of 1.4 percent of intermediate systems reported test results for any particular constituent.

Regional variation in general reference features of intermediate systems

Intermediate systems were not distributed evenly in the four regions of the US. In fact, 46.3 percent of all intermediate systems in the nation were located in the South (391,000 systems). The North Central had 22.6 percent of the nation's intermediate systems (191,000), while the Northeast had 17.0 percent (144,000) and the West had 14.1 percent (119,000).

In each region, intermediate systems overwhelmingly consisted of two-connection systems (see Table VII-53). Together, two-connection and three-

Table VII-52

Year of Most Recent Chemical and Physical Water Quality Test Among Intermediate Systems

Year of Most Recent Test	Nation	
	Number of Systems	Percent of Systems
1970 or earlier	8,000	9.2
1972	4,000	5.2
1973	7,000	8.9
1974	9,000	10.9
1975	1,000	1.5
1976	13,000	16.2
1977	9,000	10.8
1978	26,000	32.0
Unknown	5,000	5.2
*Total	82,000	99.9

*Table includes only those intermediate systems which reported conducting chemical water quality tests (9.7 percent of all intermediate systems).

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-53

Regional Variation in Number of Connections for Intermediate Systems

Number of Connections	Number and Percent of Systems			
	Northeast	North Central	South	West
2	106,000 73.6%	162,000 84.9%	300,000 76.9%	77,000 64.7%
3	21,000 14.4%	17,000 8.7%	61,000 15.7%	26,000 21.5%
4 - 14	17,000 12.1%	12,000 6.4%	29,000 7.4%	17,000 13.8%
Total	144,000 100.1%	191,000 100.0%	391,000 100.0%	119,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

connection systems amounted to at least 86.2 percent of the intermediate systems in each region. Larger intermediate systems (four through fourteen connections) were relatively uncommon, but were found more often in the Northeast and West than in the North Central and South. The West had the greatest proportion of systems with four through fourteen connections (13.8 percent), though the proportion in the Northeast was nearly as large (12.1 percent).

Very few intermediate systems across the US (less than 2 percent) metered their connections for water usage. However, in the West, the proportion of metered intermediate systems was 6.3 percent.

As would be expected from the prominence of two-connection and three-connection systems everywhere, most intermediate systems in each region had one kilometer or less of service lines. In the Northeast, 87.3 percent of intermediate systems had one kilometer or less of service lines. In the South, the proportion was 82.7 percent. In the North Central and West, the proportions were 71.1 percent and 72.2 percent, respectively. In three regions, the proportions of systems with two through ten kilometers of service lines were small: 4.5 percent in the Northeast, 2.2 percent in the North Central, 3.3 percent in the South. In the West, however, 17.0 percent of intermediate systems had from two through eight kilometers of service lines, and none had more than eight. About 5 percent of intermediate systems in each of the other three regions had eleven kilometers or more of service lines. (Length of service lines was not known for about 22 percent of intermediate systems in the North Central, so that the findings for the North Central are less reliable than the findings for other regions. Information also was unavailable for about 11 percent of intermediate systems in the West, 9 percent in the South, and 4 percent in the Northeast.)

In each region, groundwater was by far the most prominent source of water used by intermediate systems (see Table VII-54). Proportions ranged from 88.2 percent in the West to 97.0 percent in the North Central. Relatively few

Table VII-54

Regional Variation in Source of Water, Ownership, and Age for Intermediate Systems

	Number and Percent of Systems			
Characteristic	Northeast	North Central	South	West
Source				
Groundwater	136,000 94.3%	185,000 97.0%	352,000 90.0%	105,000 88.2%
Surface water	11,000 7.4%	6,000 3.0%	39,000 9.9%	14,000 11.8%
Purchased	3,000 2.0%	0 0.0%	300 0.1%	0 0.0%
Total	144,000 *	191,000 100.0%	391,000 100.0%	119.000 100.0%
Ownership				
Individual	123,000 85.7%	176,000 92.3%	367,000 94.1%	98,000 82.4%
Cooperative	19,000 12.9%	10,000 5.0%	10,000 2.5%	10,000 8.4%
Private firm	400 0.3%	2,000 1.0%	2,000 0.4%	10,000 8.1%
Public	2,000 1.1%	0 0.0%	6,000 1.5%	400 0.3%
Indian tribe	0 0.0%	0 0.0%	0 0.0%	900 0.8%
Other	0 0.0%	0 0.0%	6,000 1.5%	0 0.0%
Could not be determined	0 0.0%	3,000 1.7%	500 0.1%	0 0.0%
Total	144,000 100.0%	191,000 100.0%	391,000 100.1%	119,000 100.0%

Table VII-54 continued

Characteristic	Number and Percent of Systems Northeast	North Central	South	West
Age of System (number of years since construction or alteration)				
Less than 1	6,000 4.3%	7,000 3.5%	31,000 8.0%	2,000 1.6%
1 - 5	50,000 34.7%	42,000 22.0%	162,000 41.4%	28,000 23.6%
6 - 10	18,000 12.4%	49,000 25.5%	80,000 20.4%	27,000 22.9%
11 - 20	15,000 10.7%	35,000 18.4%	78,000 19.9%	29,000 24.6%
21 - 50	35,000 24.6%	19,000 10.0%	37,000 9.4%	18,000 15.0%
More than 50	7,000 4.7%	14,000 7.3%	0 0.0%	6,000 5.0%
Continuous improvements	2,000 1.1%	0 0.0%	0 0.0%	0 0.0%
Could not be determined	11,000 7.5%	25,000 13.3%	3,000 0.8%	9,000 7.3%
Total	144,000 100.0%	191,000 100.0%	391,000 100.0%	119,000 100.0%

*Total for source of water exceeds 100 percent since some systems relied on multiple sources.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

intermediate systems used surface water, though it was used by greater proportions of systems in the South and West and used least commonly in the North Central. Water was purchased by 2 percent of systems in the Northeast (3,000 systems) and by a few systems in the South (0.1 percent, or 300). Some intermediate systems in the Northeast (about 5,000) used multiple sources of water.

As would be expected, intermediate systems were predominantly individually owned (see Table VII-54). Nonetheless, there was some regional variation in forms of ownership. For instance, 12.9 percent of intermediate systems in the Northeast were reported to be cooperatives; cooperative ownership was reported by 8.4 percent of intermediate systems in the West, 5.0 percent in the North Central, and 2.5 percent in the South. Ownership was by a private firm at 8.1 percent of intermediate systems in the West, compared to 1 percent or less in the other regions. A small proportion of intermediate systems in the West were owned by Indian tribes (0.8 percent, or 900 systems). Relatively few systems reported any other type of ownership.

The age of water supply systems was defined in the NSA as the number of years since the system's last major alteration or, if a system had undergone no major alterations, the number of years since original construction. Regional data on the age of intermediate systems are displayed in detail in Table VII-54, but differences are most easily portrayed by median estimates. In terms of median age, the most significant finding was that intermediate systems in the South were much newer than systems located in any other region. In the South, the median age was approximately 5.5 years, compared to 8.4 in the Northeast, 7.7 in the North Central, and 10.3 in the West.

Most intermediate systems—two-thirds or more in each region—could not provide information about water usage. Median figures based on information that was available showed some broad regional differences, however. The median for average daily use was highest in the West (1,896 liters, or about 500 gallons) and second highest in the South (1,137 liters, or about 300 gallons). Medians were 770 liters (about 200 gallons) in the North Central, and 387 liters (about 100 gallons) in the Northeast. A more detailed presentation of the data is given in Table VII-55.

Figures for intermediate systems' maximum design capacity also were based on only one-third or fewer of the intermediate systems in each region (see Table VII-55). Almost all systems that could provide information in the Northeast reported a capacity of 50,000 liters or less. Larger capacities were reported by 13.8 percent of intermediate systems in the North Central, 5.4 percent in the South, 2.5 percent in the Northeast, and—surprisingly—29.0 percent of intermediate systems in the West. (Again, it must be emphasized that data on intermediate system water use should be interpreted cautiously because of the large proportions of systems which could not provide information.)

In terms of medians, maximum design capacity showed the same regional pattern as average daily use data. Medians were well above 100,000 liters (more than 26,400 gallons) in the West and South, compared to 43,400 liters (11,465 gallons) in the North Central, and only 16,000 liters (about 4,227 gallons) in the Northeast.

Regional variation in external engineering features of intermediate systems

Presented in this section are the regional findings on the engineering features of intermediate system wells and springs. Regional variation in engineering characteristics of systems using surface water and precipitation are excluded because the numbers of systems involved were so small. (Only 15,000 intermediate systems across the nation used surface water, and only 3,000 used precipitation.) Furthermore, cistern supplies were encountered in the NSA only in the Northeast.

Table VII-55

Regional Variation in Average Daily Use and Maximum Daily Design Capacity of Intermediate Systems

Quantity in Liters	Approximate Quantity in Gallons	Percent of Systems			
		North-east	North Central	South	West
Average Daily Use					
1 - 500	132 or less	14.0	13.6	5.8	6.7
501 - 1,000	133 - 264	12.0	4.8	0.0	0.0
1,001 - 5,000	265 - 1,320	0.6	13.8	5.7	2.7
More than 5,000	More than 1,321	1.1	0.0	1.3	4.7
Could not be determined		72.3	67.7	87.1	85.8
Total		100.0	99.9	99.9	99.9
		144,000	191,000	391,000	119,000
Maximum Daily Design Capacity					
1 - 25,000	6,604 or less	13.8	10.4	4.8	2.4
25,001 - 50,000	6,605 - 13,208	7.1	9.5	0.5	1.8
50,001 - 100,000	13,209 - 26,417	0.3	9.5	0.0	7.9
100,001 - 500,000	26,418 - 132,086	2.2	3.3	4.9	14.0
More than 500,000	More than 132,086	0.0	1.0	0.5	7.1
Could not be determined		76.5	66.4	89.2	66.7
Total		99.9	100.1	99.9	99.9
		144,000	191,000	391,000	119,000

Regional distribution of intermediate system wells and springs

Though wells were by far the most common supply used by intermediate systems in each region, the proportions relying on wells ranged from 81.9 percent in the Northeast to 96.9 percent in the North Central (see Table VII-56). Springs provided water to 15.2 percent of intermediate systems in the Northeast, 12.2 percent in the South, and 9.9 percent in the West. The NSA sample included no intermediate systems in the North Central which used springs.

Regional variation in sites of intermediate system wellheads

Data on intermediate system wellhead arrangements showed substantial regional variation (see Table VII-57). For instance, only 39.0 percent of intermediate system wells in the Northeast terminated above ground, compared to 62.3 percent in the North Central, 78.5 percent in the South, and 75.6 percent in the West (see Table VII-57). The South had the largest proportion of wells terminating above ground and having no protective cover (18.6 percent of intermediate wells in the South).

Compared with the other three regions, the Northeast had a greater proportion of wells that were situated in well pits (28.7 percent, or 34,000 intermediate wells). The well pit is not a generally recommended arrangement because a pit provides a natural indentation for water accumulation. However, pits can be improved by installing watertight covers or by installing drains to remove accumulated water around the wellhead. As shown in Table VII-57, more pits in the Northeast lacked a watertight cover than had one. As for drains, in the Northeast, about 59 percent of intermediate wells situated in pits drained to open ground, and about 2 percent drained into a sewer line; however, 38 percent had no drain (not reflected in Table VII-57). As for other regions, the West also showed more wells lacking watertight covers than having them, but there were fewer wells situated in pits; on the other hand, none of the well pits in the West had a drain. In the North

Table VII-56

Regional Distribution of Intermediate System Wells and Springs

	Number and Percent of Systems*			
	Northeast	North Central	South	West
Wells	118,000 81.9%	185,000 96.9%	338,000 86.4%	104,000 87.4%
Springs	22,000 15.2%	0 0.0%	48,000 12.2%	12,000 9.9%

*Percentages are based on the number of intermediate systems in each region; percentages do not total 100 percent since supplies using surface water and precipitation are excluded.

Table VII-57

Regional Variation in Wellhead Arrangements for Intermediate System Wells

Classification	Northeast	North Central	South	West
	Number and Percent of Systems			
Terminated above ground				
Protected by shed, roof or other structure	35,000 29.6%	99,000 53.2%	202,000 59.9%	64,000 61.6%
Uncovered	11,000 9.4%	17,000 9.1%	63,000 18.6%	15,000 14.0%
Subtotal	46,000 39.0%	116,000 62.3%	265,000 78.5%	79,000 75.6%
Situated in well pit				
Pit without watertight cover	20,000 16.8%	10,000 5.6%	7,000 2.0%	8,000 7.9%
Pit with watertight cover	14,000 11.9%	9,000 5.0%	15,000 4.3%	3,000 3.0%
Subtotal	34,000 28.7%	19,000 10.6%	22,000 6.3%	11,000 10.9%
Buried	24,000 20.3%	35,000 18.7%	26,000 7.7%	4,000 4.3%
Situated in household	5,000 4.4%	3,000 1.7%	10,000 3.1%	3,000 2.5%
Miscellaneous arrangements	0 0.0%	4,000 2.0%	6,000 1.6%	800 0.8%
Arrangements could not be determined	9,000 7.6%	9,000 4.7%	9,000 2.7%	6,000 5.8%
Total	118,000 100.0%	186,000 100.0%	338,000 99.9%	104,000 99.9%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Central, more than 50 percent of the well pits had no drain. In the South, two-thirds of the well pits drained to open ground and one-third had no drain.

Intermediate systems using buried wells were proportionately most common in the Northeast and North Central, but in terms of numbers, the South was about equal with those two regions (see Table VII-57). In the West, only about 4,000 intermediate wells (4.3 percent) were buried. Less than 5 percent of intermediate wells in any region were situated within the house.

Regional variation in construction of intermediate system wells

Drilled wells were by far the most common in every region, though there was some variation in the proportions (see Table VII-58). Specifically, about 70 percent of intermediate wells in the Northeast and North Central were drilled, compared to 61.4 percent in the South and 57.7 percent in the West. As for other types of construction, bored wells were most common in the South (16.8 percent of intermediate wells in that region), while dug wells were most common in the Northeast (17.2 percent of intermediate wells there). A sizable proportion of intermediate wells in the West also were dug (10.7 percent). Driven wells and jetted wells were less common overall, but also showed regional differences in use. For large proportions of intermediate wells in the West and North Central, the type of construction could not be determined, and the data for well construction in these two regions should be interpreted cautiously.

Regional variation in age of intermediate system wells

As explained earlier, age was defined in the NSA as the number of years since a system's last major alteration or, if a system had undergone no major alterations, the number of years since original construction. Whereas intermediate systems of all kinds had a lower median age in the South (5.5 years), intermediate system wells in the South had a median age of roughly eleven years. Intermediate

Table VII-58

Regional Variation in Construction of Intermediate System Wells

Type of Construction	Number and Percent of Systems Northeast	North Central	South	West
Drilled	83,000 69.9%	131,000 70.6%	207,000 61.4%	60,000 57.7%
Bored	5,000 4.0%	4,000 2.2%	57,000 16.8%	0 0.0%
Dug	20,000 17.2%	9,000 4.9%	21,000 6.3%	11,000 10.7%
Driven	4,000 3.7%	6,000 3.2%	12,000 3.6%	0 0.0%
Jetted	0 0.0%	0 0.0%	13,000 4.0%	2,000 2.2%
Could not be determined	6,000 5.2%	35,000 19.1%	27,000 8.0%	30,000 29.3%
Total	118,000 100.0%	185,000 100.0%	338,000 100.1%	104,000 99.9%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

system wells in the Northeast had about the same median age as those in the South. By contrast, intermediate wells in the North Central and West had a median age of about seven years.

According to an EPA survey,[21] there tends to be an increased risk of contamination in wells more than twenty years old. As indicated in Table VII-59, which presents the regional variation in age of intermediate wells, a significant proportion of wells in each region were more than twenty years old: 28.6 percent in the Northeast, 22.1 percent in the West, 17.6 percent in the North Central, and 17.0 percent in the South. Data were unavailable for substantial proportions of intermediate wells in the North Central and West, so that the proportions of wells over twenty years old may in fact be higher than those given.

Regional variation in depth of intermediate system wells

The EPA recommends that wells be at least ten feet deep to filter water as it percolates down through layers of soil.[22] In general, although dependent on soil type, deeper wells are less likely to be subject to contamination. The median depth of intermediate system wells showed sharp regional differences. The deepest wells were located in the West (38.5 meters, or about 126 feet), and the shallowest in the North Central (23.9 meters, or about 78 feet). The median well depth in the South and Northeast was about 30 meters (nearly 100 feet).

In regard to the minimum depth recommended by the EPA, 7.1 percent of intermediate wells in the Northeast were about ten feet deep. (It was reported earlier that about 17 percent of intermediate wells in the Northeast were dug wells.) A very small proportion of intermediate wells in the South—0.7 percent—were ten feet or less in depth. No intermediate wells were this shallow in the North Central or West.

Table VII-59

Regional Variation in Age of Intermediate System Wells

Age (Number of Years Since Construction or Alteration)	Number and Percent of Systems			
	Northeast	North Central	South	West
5 or less	39,000 33.4%	63,000 34.0%	100,000 29.7%	34,000 32.3%
6 - 10	15,000 12.3%	26,000 14.3%	49,000 14.5%	13,000 12.3%
11 - 15	10,000 8.2%	6,000 3.4%	72,000 21.4%	6,000 5.7%
16 - 20	12,000 10.2%	15,000 8.3%	29,000 8.6%	1,000 1.4%
21 - 50	27,000 22.5%	17,000 9.0%	58,000 17.0%	17,000 16.3%
More than 50	7,000 6.1%	16,000 8.6%	0 0.0%	6,000 5.8%
Could not be determined	9,000 7.5%	42,000 22.4%	30,000 8.8%	27,000 26.3%
Total	118,000 100.2%	185,000 100.0%	338,000 100.0%	104,000 100.1%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Regional variation in casing diameter for intermediate system wells

For the US, NSA findings indicated the prevalence of certain standard even-size casing—two-inch, four-inch, six-inch, and eight-inch. Regional estimates of well casing diameter also reflected standard size casing. In the Northeast, South, and West, the medians were 15.2 centimeters (six inches), while in the North Central, the median casing size was 10.2 centimeters (four inches).

Regional variation in grouting of intermediate system wells

Grouting, which seals the space between the well casing and the soil around it, provides important protection against contamination in certain circumstances (see "Grouting in individual wells"). The West had the greatest proportion of intermediate wells that were grouted (46.0 percent). In the three other regions, proportionately more intermediate wells lacked grouting than had it (see Table VII-60). The Northeast and South had the greatest proportions of intermediate wells which were known not to have grouting. Viewed the other way, the North Central had the smallest proportion of intermediate wells known to have grouting. However, results for the North Central cannot be considered reliable because it could not be determined whether grouting was present or not in almost half of the intermediate wells in that region.

Regional variation in wellhead sealing against pollutants

Wellhead sealing was evaluated in the NSA in terms of three different factors (see Table VII-61). With regard to general acceptability of the well cover, there was considerable regional variation. The South had the greatest proportion of well covers which were judged unacceptable (24.2 percent), but the proportion in the Northeast was almost as large (20.4 percent). Comparable percentages were 12.9 percent in the West and 2.2 percent in the North Central.

Table VII-60

Regional Variation in Grouting of Intermediate System Wells

	Number and Percent of Systems*			
Grouting	Northeast	North Central	South	West
Not grouted	46,000 47.5%	48,000 27.8%	140,000 44.4%	30,000 35.1%
Grouted	27,000 29.9%	43,000 24.7%	124,000 39.2%	40,000 46.0%
Could not be determined	22,000 22.6%	83,000 47.5%	51,000 16.3%	16,000 18.9%
Total	96,000	174,000	315,000	87,000
	100.0%	100.0%	99.9%	100.0%

*Table includes only those wells which were drilled, driven, bored, or jetted. The question was not applicable for wells which were dug.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-61

Regional Variation in Adequacy of Wellhead Sealing and Source Protection in Intermediate System Wells

	Number and Percent of Systems			
Characteristic	Northeast	North Central	South	West
Cover (general acceptability)				
Acceptable	82,000 69.6%	166,000 89.5%	238,000 70.4%	82,000 79.2%
Unacceptable	24,000 20.4%	4,000 2.2%	82,000 24.2%	13,000 12.9%
Could not be determined	12,000 9.9%	15,000 8.3%	18,000 5.4%	8,000 7.8%
Total	118,000 99.9%	185,000 100.0%	338,000 100.0%	104,000 99.9%
Cover (splashproof or not)				
Splashproof	76,000 64.3%	169,000 91.3%	244,000 72.2%	78,000 75.2%
Not splashproof	28,000 23.6%	7,000 3.9%	70,000 20.8%	18,000 17.0%
Could not be determined	14,000 12.0%	9,000 4.7%	24,000 7.0%	8,000 7.8%
Total	118,000 99.9%	185,000 99.9%	338,000 100.0%	104,000 100.0%
Source protection				
Adequately protected	88,000 74.7%	168,000 90.9%	227,000 67.2%	88,000 84.9%
Not adequately protected	21,000 17.7%	4,000 1.9%	88,000 26.1%	8,000 7.3%
Could not be determined	9,000 7.6%	13,000 7.1%	22,000 6.6%	8,000 7.8%
Total	118,000 100.0%	185,000 99.9%	338,000 99.9%	104,000 100.0%

Table VII-61 continued

Characteristic	Number and Percent of Systems Northeast	North Central	South	West
Combined evaluation				
Acceptable on all three factors	73,000 61.6%	155,000 83.6%	194,000 57.6%	75,000 72.4%
Unacceptable on one factor	9,000 8.0%	6,000 3.3%	25,000 7.4%	7,000 6.9%
Unacceptable on two factors	6,000 5.4%	4,000 2.4%	28,000 8.3%	9,000 8.4%
Unacceptable on all three factors	15,000 12.9%	0 0.0%	53,000 15.7%	5,000 4.5%
Could not be determined	14,000 12.0%	20,000 10.7%	37,000 11.1%	8,000 7.8%
Total	118,000 99.9%	185,000 100.0%	338,000 100.1%	104,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

The second consideration in judging the adequacy of wellhead sealing was whether or not the cover was splashproof—that is, whether the cover kept runoff from entering the inside of the well casing. On this factor, too, the Northeast and South had the greatest proportions of wells that were not acceptable (see Table VII-61). Proportions of intermediate wells with covers that were not splashproof were 23.6 percent in the Northeast, 20.8 percent in the South, 17.0 percent in the West, and 3.9 percent in the North Central.

Likewise, on the factor of source protection, the South and the Northeast had the greatest proportions of intermediate wells that were judged not acceptable. The source was judged to be inadequately protected for 26.1 percent of intermediate wells in the South and 17.7 percent of intermediate wells in the Northeast, compared to 7.3 percent in the West and 1.9 percent in the North Central.

The combined evaluation of wellhead sealing and source protection, which tabulated ratings on all three factors together, made even more striking what was evident from the separate ratings—that the best conditions were found in intermediate wells in the North Central, while the worst were found in the South and the Northeast (see combined evaluation, Table VII-61). The North Central had the highest proportion of intermediate wells that were judged acceptable on all three factors, and showed no intermediate wells that were unacceptable on all three. By contrast, the South had 57.6 percent of its intermediate wells judged acceptable on all three factors, and 15.7 percent judged unacceptable on all three. The Northeast had 61.6 percent acceptable on all three factors, and 12.9 percent unacceptable on all three.

Regional variation in distance to potential pollution sources for intermediate system wells

EPA has recommended that wells be located at least 50 feet (about sixteen meters) away from any potential source of contamination.[23] The national findings about intermediate wells and potential sources of pollution indicated that sewage disposal systems and oil or gasoline tanks were the most common potential problems. Other possible sources either occurred less frequently or were not easily observed by interviewers as they inspected the wells.

Table VII-62 reports the regional variation in the proportions of intermediate system wells within sixteen meters of observed potential pollution sources. Interestingly, the North Central had higher proportions of intermediate wells within sixteen meters of sewage disposal systems and fuel tanks than did other regions. Animal waste was more commonly observed in the Northeast and South than in the North Central or West, although the differences were not as pronounced. Agricultural fertilizer or runoff was observed most often in the West, while potential sources of surface water contamination and highway salt were observed most frequently in the Northeast.

Regional variation in access to well equipment (pitless adapter, buried seal)

Pitless adapters are preferred over buried seals because they permit access to wells for inspection, servicing, and testing. As shown in Table VII-63, 27.9 percent of intermediate wells in the North Central were equipped with pitless adapters. This proportion was higher than in any other region. In the Northeast, 18.6 percent of intermediate wells had pitless adapters, compared to 11.9 percent in the West and 10.8 percent in the South.

Buried seals are undesirable for several reasons. They inhibit inspection of the wellhead, and they increase the risk of damage to the wellhead—and likely contamination—because servicing requires excavation. In the Northeast and North

Table VII-62

Regional Variation in Intermediate System Wells Within Sixteen Meters of Potential Pollution Sources

Type of Pollution Source	Number and Percent of Systems*			
	Northeast	North Central	South	West
Sewage disposal system	21,000 18.1%	47,000 25.5%	35,000 10.5%	15,000 14.4%
Oil or gasoline tank	16,000 13.7%	38,000 20.5%	38,000 11.2%	12,000 11.7%
Animal waste	13,000 11.0%	14,000 7.8%	34,000 10.2%	6,000 5.9%
Agricultural fertilizer or runoff	4,000 3.1%	8,000 4.4%	23,000 6.9%	10,000 9.4%
Surface water contamination (such as pond, lake, or river which might flood into well)	13,000 11.1%	9,000 4.9%	10,000 2.9%	2,000 2.0%
Highway salt	7,000 6.1%	3,000 1.8%	1,000 0.4%	**
Industrial waste	2,000 2.1%	3,000 1.8%	10,000 3.1%	**
Other contamination	5,000 3.9%	7,000 3.6%	6,000 1.9%	9,000 8.6%
Total Systems	118,000	185,000	338,000	104,000

*Percentages are based on the number of intermediate system wells in each region.

**Indicates that source of contamination was not observed during inspection.

Table VII-63

Regional Variation in Use of Pitless Adapter and Buried Seal in Intermediate System Wells

	Number and Percent of Systems			
Well Equipment	Northeast	North Central	South	West
Pitless adapter	22,000 18.6%	52,000 27.9%	36,000 10.8%	12,000 11.9%
Buried seal	24,000 20.3%	35,000 18.7%	39,000 11.7%	5,000 4.7%
Neither	60,000 50.4%	70,000 37.6%	235,000 69.7%	61,000 58.4%
Could not be determined	13,000 10.6%	29,000 15.9%	26,000 7.8%	26,000 25.0%
Total	118,000 99.9%	185,000 100.1%	338,000 100.0%	104,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Central, about one out of five intermediate wells had buried seals, compared to 11.7 percent in the South and only 4.7 percent in the West.

Large proportions of intermediate wells in each region had neither pitless adapter nor buried seal. The lack of such devices did not imply any necessary problem, however, since other techniques for protection against pollution may have been in use. Information regarding pitless adapters and buried seals could not be obtained for many intermediate wells. This was a particular problem in the West, where information was missing for 25.0 percent of intermediate wells. Either the respondent could not provide the information, or it was impossible to identify the well equipment during physical inspection of the supply.

Regional distribution of intermediate system springs

As reported in Table VII-56, the South had the largest number of intermediate systems that used springs (about 48,000); nonetheless, such systems amounted to only 12.2 percent of all intermediate systems in that region. The Northeast had 22,000 intermediate systems using springs, or 15.2 percent of all intermediate systems in the Northeast. The West had 12,000 spring systems, or 9.9 percent of all intermediate systems in the West. No intermediate systems using springs were found in the North Central. This may have been an accident of the NSA sample, but it is reasonable to assume that such systems were at least rare in the North Central. The following sections, then, contain no data for intermediate systems using springs in the North Central.

Regional variation in intrusion protection for intermediate system springs

Just as with wells, springs should be protected from the elements and from sources of possible contamination. For example, springhouses can be constructed to protect against surface contamination. If a spring has some type of underground reservoir, it should have a cover that can be removed for cleaning. NSA findings, however, showed that springs with unacceptable covers were far more common than adequately protected springs. In fact, in the NSA sample, every spring supplying an intermediate system in the West had an unacceptable cover. About 76 percent of those in the South had unacceptable covers, as did about 58 percent in the Northeast.

Source protection data showed the same pattern. None of the intermediate system springs in the West had adequate source protection. About 65 percent of intermediate system springs in the South had inadequate source protection, as did 46.4 percent of those in the Northeast. (In the Northeast, 53.6 percent did have adequate source protection.)

Regional variation in distance to potential pollution sources
for intermediate system springs

For the purposes of the NSA, springs were described with regard to the distance between them and potential sources of pollution. Here, regional differences are presented in the proportions of intermediate system springs that were within 30 meters (100 feet) of possible pollution sources. As shown in Table VII-64, many types of pollution sources either were absent in a region, or were not visible to the interviewer.

Two sources of potential pollution were present in each region having an intermediate system spring. Possible surface water contamination (from the area surrounding the spring) was noted for about one-third of the intermediate springs in the Northeast and West, and for about 14 percent of those in the South. Sewage disposal systems were within 30 meters of 3,000 intermediate system springs in the West (27.1 percent of the intermediate springs in that region), and also were noted for intermediate springs in the Northeast and South, though only for small proportions of intermediate springs. There was animal waste within 30 meters of about 10,000, or about 20 percent, of intermediate springs in the South.

Table VII-64

Regional Variation in Intermediate System Springs Within 30 Meters of Potential Pollution Sources

	Number and Percent of Systems*		
Type of Pollution Source	Northeast	South	West
Sewage disposal system	700 3.0%	1,000 2.4%	3,000 27.1%
Oil or gasoline tank	0 0.0%	**	**
Animal waste	0 0.0%	10,000 20.4%	0 0.0%
Agricultural fertilizer or runoff	0 0.0%	**	**
Surface water contamination (such as pond, lake, or river which might flood into spring)	8,000 35.0%	7,000 14.1%	4,000 36.6%
Highway salt	0 0.0%	**	**
Industrial waste	**	**	**
Other contamination	**	7,000 15.0%	**
Total Systems	22,000	48,000	12,000

*Since the NSA sample included no intermediate system springs in the North Central, that region is excluded from the table.

**Indicates that source of contamination was not observed during inspection.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Regional variation in general system considerations for all intermediate systems

Regional variation in methods for water distribution in intermediate systems

Most intermediate systems in the US (about 90 percent) used electric pumps to propel water through the system, and there was little regional variation in that proportion. Regional differences were evident in the proportions of systems using gravity flow and artesian pressure, however. Intermediate systems relying on gravity flow were most common in the West (12.0 percent of intermediate systems there), but also occurred in the South (5.9 percent), Northeast (4.8 percent), and North Central (1.0 percent). All the intermediate systems which used artesian pressure that were encountered in the NSA were located in the West (2.4 percent of intermediate systems there).

Regional variation in water distribution and treatment devices

As explained in the national findings, at the time of their original construction, intermediate systems acquired basic equipment such as distribution lines and water sources. Also, most systems installed pumps at that time.

In addition, a variety of other original equipment was installed, including pressure tanks, storage tanks, and reservoirs. Pressure tanks were most often installed as original equipment in the Northeast and South (at about 40 percent of the systems in each of those regions), while storage tanks were installed as original equipment far more frequently in the West (at about 32 percent of systems). Only in the South were reservoirs installed at the time of original construction.

Treatment facilities were installed as original equipment in relatively few intermediate systems in any region, with regional proportions ranging from 6.5 percent in the Northeast to 3.2 percent in the South. In addition to compiling data on treatment facilities that were installed as original equipment in intermediate systems, the NSA gathered information on specific treatment processes and equipment that the systems were using. While a treatment process could include any treatment that was conducted by the system on a regular basis, data on treatment devices were restricted to those in operation at the time of the NSA interview.

From national results, it was clear that few intermediate systems performed any treatment; when they did, treatment generally consisted of chlorination, softening, or filtration. The Northeast had the greatest proportion of intermediate systems practicing any kind of treatment—15.4 percent. Comparable proportions were 10.0 percent in the South, 8.2 percent in the West, and 7.6 percent in the North Central.

As for specific kinds of treatment, softening was the most common (see Table VII-65). Softening was performed at 7.8 percent of intermediate systems in the South, 6.6 percent in the Northeast, 4.5 percent in the West, and 2.8 percent in the North Central. Chlorination was practiced at 5.7 percent of intermediate systems in the Northeast, 3.7 percent in the West, and 2.9 percent in the South. No intermediate systems in the North Central that were included in the NSA sample chlorinated their water. Filtration and other kinds of treatment were reported by less than 4 percent of intermediate systems in any region.

Small differences were evident between the proportions of systems reporting specific types of treatment processes and the proportions where related devices were actually operating at the time of the NSA (see Table VII-65). The biggest difference—a matter of 3.4 percent—was seen between the proportions reporting chlorination and those having operating chlorinators in the Northeast.

Regional variation in intermediate system operators

Most intermediate systems across the US had only one operator or had none at all. Still, there was considerable regional variation with regard to the number of intermediate system operators, as shown in Table VII-66. For instance, more than half of the intermediate systems in the North Central reported having no operator,

Table VII-65

Regional Variation in Water Treatment Processes and Devices Among Intermediate Systems

	Number and Percent of Systems*			
Characteristic	Northeast	North Central	South	West
Treatment Processes				
Filtration	4,000 3.0%	6,000 2.9%	14,000 3.7%	100 0.1%
Softening	10,000 6.6%	5,000 2.8%	31,000 7.8%	5,000 4.5%
Chlorination	8,000 5.7%	0 0.0%	11,000 2.9%	4,000 3.7%
Other treatment	0 0.0%	6,000 3.0%	0 0.0%	0 0.0%
Treatment Devices				
Activated carbon or anthracite filter	4,000 3.0%	3,000 1.8%	0 0.0%	100 0.1%
Softener	10,000 6.6%	5,000 2.8%	27,000 6.9%	5,000 4.5%
Chlorinator	3,000 2.3%	0 0.0%	8,000 2.1%	3,000 2.5%
Miscellaneous filter	2,000 1.7%	11,000 6.0%	4,000 1.0%	0 0.0%
Other devices	2,000 1.7%	0 0.0%	3,000 0.7%	0 0.0%
Total Systems	144,000	191,000	391,000	119,000

*Table reports systems having at least one treatment process or device.

Table VII-66

Regional Variation in Number and Work Status of Operators of Intermediate Systems

	Number and Percent of Systems			
Characteristic	Northeast	North Central	South	West
Number of Operators				
0	59,000 40.8%	107,000 55.8%	101,000 25.8%	33,000 27.3%
1	51,000 35.7%	76,000 39.7%	208,000 53.4%	77,000 64.4%
2	23,000 15.7%	6,000 3.3%	66,000 16.8%	2,000 1.9%
3 - 5	11,000 7.8%	2,000 1.1%	13,000 3.3%	3,000 2.8%
Could not be determined	0 0.0%	0 0.0%	3,000 0.7%	4,000 3.6%
Total Systems	144,000 100.0%	191,000 99.9%	391,000 100.0%	119,000 100.0%
Status of Operators*				
Volunteer	75,000 86.0%	72,000 85.0%	249,000 85.9%	67,000 78.6%
Paid part-time	8,000 8.9%	6,000 7.5%	21,000 7.3%	19,000 22.8%
Paid full-time	100 0.1%	3,000 4.1%	1,000 0.5%	4,000 4.2%
Could not be determined	4,000 5.0%	3,000 3.4%	18,000 6.1%	0 0.0%
Total Systems	87,000	84,000	290,000	85,000

*Percentages (status of operators) are based on the total number of systems which had operators; percentages do not add to 100 percent because, for example, some systems may have used both full-time and part-time operators.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

compared to approximately one-quarter of those in the South and West. Almost two-thirds of the intermediate systems in the West had one operator, and less than 5 percent had two or more. In the North Central, about 40 percent had one operator, and less than 5 percent had two or more. By contrast, 23.5 percent of intermediate systems in the Northeast, and 20.1 percent of intermediate systems in the South, had two or more operators.

Most intermediate systems used volunteer operators; proportions ranged from 78.6 percent volunteer in the West to 86.0 percent in the Northeast (see Table VII-66). The West had a much greater proportion of systems using paid part-time operators than did the other regions (22.8 percent, compared to between 7 and 9 percent in the other regions). Less than 5 percent of intermediate systems in any region had paid, full-time workers.

Corresponding to the prevalence of volunteer operators, almost all intermediate system operators were untrained. In fact, only about 3 percent of all intermediate systems in the US had specially trained operators. Regional estimates were very close to the national figure, except that the proportion in the West was even smaller (1.6 percent).

In terms of the number of man-days required for operation and maintenance of intermediate systems, nearly all systems in each region were reported to require one man-day or less per month. Small regional differences were reported in the number of systems requiring one man-day per month as opposed to none at all, but the proportional differences were inconsequential.

Regional variation in system performance

System performance was assessed in two ways—the number of breakdowns that had occurred during the year prior to the NSA, and the amount of difficulty the system had in obtaining water from the source.

On the national level, about one in four intermediate systems had experienced breakdowns in the year preceding the NSA, and the majority of these had had only one. In the regional comparison, intermediate systems in the Northeast were the most reliable, as can be seen in Table VII-67. Eleven percent of the intermediate systems in the Northeast had experienced one breakdown, and 10.3 percent had had from two through six. Intermediate systems in the North Central had a similar record: 11.1 percent reported one breakdown, and 12.8 percent reported having either two or three. Also, among intermediate systems in the South, 18.7 percent reported one breakdown, and 7.2 percent reported having from two through fifteen. The record for intermediate systems in the West was not as good: 24.2 percent reported having one breakdown, and 9.1 percent reported having two or more, with a maximum of more than 95 (the coding limit in the NSA).

Though system breakdowns do not necessarily imply a loss of service to water users (in the case of a pump malfunction, for instance, a system might continue operating with an auxiliary pump), most breakdowns among intermediate systems apparently had. Among intermediate systems in the West, 33.3 percent had experienced at least one breakdown, and 27.6 percent reported that a breakdown had resulted in loss of service to users. In the South, 25.9 percent of intermediate systems had had breakdowns, and about 24 percent reported a loss of service to users. Comparable proportions in the North Central were 23.9 percent and about 20 percent; in the Northeast, they were 21.3 percent and about 19 percent.

Breakdowns in the system were most frequently attributed to pump malfunctions, ruptured lines, and power failures, as shown in Table VII-67. Pump malfunctions were far more frequently the cause of breakdowns in the West than in other regions, being reported by about 70 percent of the systems that experienced breakdowns. Pump malfunctions were reported by about 48 percent of the systems

Table VII-67

Regional Variation in the Frequency and Reasons for Breakdowns in Intermediate Systems

	Number and Percent of Systems			
Characteristic	Northeast	North Central	South	West
Number of Breakdowns During Previous Year				
0	113,000	145,000	290,000	80,000
	78.7%	76.1%	74.2%	66.7%
1	16,000	21,000	73,000	29,000
	11.0%	11.1%	18.7%	24.2%
2 or more	15,000	24,000	28,000	11,000
	10.3%	12.8%	7.2%	9.1%
Maximum	6	3	15	95
Total	144,000	191,000	391,000	119,000
	100.0%	100.0%	100.1%	100.0%
Reasons for Breakdowns*				
Pump malfunction	7,000	13,000	49,000	28,000
	22.1%	27.6%	48.1%	70.2%
Ruptured lines	14,000	27,000	41,000	7,000
	46.0%	59.6%	40.3%	18.1%
Power failure	2,000	3,000	11,000	1,000
	5.3%	7.6%	11.0%	3.6%
Drought	1,000	0	0	2,000
	2.4%	0.0%	0.0%	4.2%
Flooding	0	0	0	2,000
	0.0%	0.0%	0.0%	4.2%
Vandalism	0	0	0	2,000
	0.0%	0.0%	0.0%	4.2%
Treatment failure	0	0	1,000	0
	0.0%	0.0%	1.1%	0.0%
Other reasons	10,000	6,000	4,000	3,000
	31.9%	12.2%	4.1%	8.0%
*Total Systems with Breakdowns	31,000	46,000	101,000	40,000

*Percentages do not add to 100 percent because, for example, some systems may have reported multiple reasons.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

in the South that had experienced breakdowns, compared to 27.6 percent in the North Central and 22.1 percent in the Northeast.

Ruptured lines had caused breakdowns more frequently in the North Central than in other regions. They were the cause of breakdowns at only 18.1 percent of the systems in the West that had experienced breakdowns. Breakdowns due to power failures were reported by 11.0 percent of systems in the South that had experienced breakdowns, compared to 7.6 percent of the systems reporting breakdowns in the North Central and lesser percentages in the Northeast and West.

On the whole, most intermediate systems had not experienced difficulties in obtaining water from the source (see Table VII-68). Of the intermediate systems in the West using groundwater, however, 8.3 percent had experienced difficulties related to weather problems. Only a small proportion of systems in the Northeast, and none at all in the North Central and South, reported weather problems causing difficulties. Equipment breakdowns resulted in loss of access to the water source in about 5 percent of intermediate systems using groundwater in the Northeast and to lesser proportions in the other regions.

Far fewer intermediate systems in each region used surface water, but in two regions—the Northeast and West—sizable proportions of these systems had experienced difficulties in obtaining water from the source. In the Northeast, the problems were related exclusively to equipment breakdowns. In the West, water contamination was the chief problem (44.3 percent of the region's intermediate systems using surface water), though weather conditions caused problems for 12.1 percent of systems. In the South, reasons for the difficulties were related to weather (9.5 percent of systems) and water unavailability (7.4 percent). No systems in the North Central which used surface water had experienced any difficulties obtaining water from the source.

Table VII-68

Regional Variation in Difficulties in Acquiring Water for Intermediate Systems Using Groundwater and Surface Water

Type of Difficulty	Number and Percent of Systems Northeast	North Central	South	West
Groundwater				
No difficulties	124,000 91.5%	176,000 94.9%	338,000 96.0%	94,000 88.9%
Equipment breakdowns	7,000 5.3%	3,000 1.7%	11,000 3.2%	4,000 4.1%
Water was unavailable	4,000 2.7%	6,000 3.3%	0 0.0%	3,000 2.7%
Weather problems	700 0.5%	0 0.0%	0 0.0%	9,000 8.3%
Loss of a supply	0 0.0%	0 0.0%	3,000 0.8%	0 0.0%
*Total	136,000	185,000	352,000	105,000
Surface water				
No difficulties	9,000 77.5%	6,000 100.0%	35,000 91.4%	6,000 43.0%
Equipment breakdowns	2,000 22.5%	0 0.0%	0 0.0%	0 0.0%
Water was unavailable	0 0.0%	0 0.0%	3,000 7.4%	100 0.7%
Weather problems	0 0.0%	0 0.0%	4,000 9.5%	2,000 12.1%
Contamination	0 0.0%	0 0.0%	0 0.0%	6,000 44.3%
*Total	11,000	6,000	39,000	14,000

*Totals reflect the number of systems supplied by each source in each region.

Regional variation in intermediate system water test history

— Bacteriological water quality tests

The majority of intermediate systems serving rural households did not perform bacteriological tests. Across the US, in fact, only 22.4 percent of all intermediate systems performed such tests. In the West, however, 48.8 percent of intermediate systems performed bacteriological tests (about 41 percent did not, and information was not available for 10.3 percent).

In the Northeast, one-third of all intermediate systems performed bacteriological tests, though two-thirds did not. In the North Central and South, only 8.3 percent and about 17 percent, respectively, had performed bacteriological tests.

Even among the small proportions of intermediate systems in each region that performed bacteriological tests, tests were performed infrequently. By far the most common situation was that the system performed such tests once a year or less often (see Table VII-69). Proportions testing once every six months or more often ranged from 15.3 percent of the intermediate systems that did testing in the West to 8.9 percent of the intermediate systems that did testing in the Northeast. (These proportions amounted to only 9,000 systems in the West and 5,000 systems in the Northeast, since only those systems performing bacteriological tests were considered for the tabulation.)

In each region, the intermediate systems that performed bacteriological tests relied most often on public health departments to conduct the tests. The proportions of systems using public health departments ranged from 43.3 percent in the South to 88.5 percent in the North Central, as shown in Table VII-69. Private laboratories were used by 26.3 percent of the systems performing tests in the Northeast, and by 17.3 percent of the intermediate systems performing tests in the West. State environmental departments performed tests for 17.1 percent of intermediate systems performing tests in the South, and 12.8 percent of intermediate systems performing tests in the Northeast. Federal laboratories did the

Table VII-69

Regional Variation in Frequency of Bacteriological Water Quality Tests Among Intermediate Systems, and Organizations Conducting the Tests

	Number and Percent of Systems*			
	Northeast	North Central	South	West
Frequency of tests				
Not performed regularly	5,000 10.6%	2,000 12.1%	11,000 16.1%	13,000 21.7%
Once a year or less	33,000 68.0%	11,000 72.4%	36,000 55.0%	34,000 57.8%
At least once every six months	0 0.0%	1,000 7.3%	3,000 3.9%	5,000 9.2%
At least once every three months	3,000 5.6%	0 0.0%	2,000 3.0%	3,000 4.3%
At least once every month	2,000 3.3%	800 5.2%	3,000 4.2%	1,000 1.8%
At least once a week	0 0.0%	0 0.0%	2,000 3.3%	0 0.0%
Could not be determined	6,000 12.5%	500 2.9%	10,000 14.5%	3,000 5.2%
Total	49,000 100.0%	16,000 99.9%	66,000 100.0%	58,000 100.0%

Table VII-69 continued

	Number and Percent of Systems*			
	Northeast	North Central	South	West
Organization conducting tests				
Public health department	27,000 55.1%	14,000 88.5%	29,000 43.3%	28,000 48.5%
Private laboratory	13,000 26.3%	0 0.0%	2,000 2.6%	10,000 17.3%
State environmental department	6,000 12.8%	500 2.9%	11,000 17.1%	5,000 8.5%
Federal laboratory	0 0.0%	0 0.0%	7,000 10.2%	0 0.0%
Hospital laboratory	0 0.0%	0 0.0%	0 0.0%	4,000 6.3%
System laboratory and either public health department or state environmental department	0 0.0%	0 0.0%	1,000 1.8%	0 0.0%
System laboratory	0 0.0%	0 0.0%	300 0.4%	0 0.0%
Other	2,000 3.3%	1,000 6.5%	10,000 14.4%	0 0.0%
Could not be determined	1,000 2.5%	300 2.1%	7,000 10.1%	11,000 19.4
Total	49,000 100.0%	16,000 100.0%	66,000 99.9%	58,000 100.0%

*Table includes only those intermediate systems which reported conducting bacteriological water quality tests.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

testing for about 10 percent of the intermediate systems in the South which performed tests. Only a few systems in the South, and none in other regions, performed their own bacteriological tests. (Again, proportions shown in Table VII-69 are based only on the small numbers of intermediate systems in each region which actually performed bacteriological tests.)

Bacteriological test results were compiled for those intermediate systems which had performed tests during the year preceding the NSA. Specifically, system respondents were asked, "Of the tests performed during the past year or of the last twelve tests, whichever is fewer, how many had acceptable results?" Most systems that performed tests could not provide results, but in two regions—the North Central and South—every intermediate system that could provide results reported that all of the tests had shown acceptable results. (Results were obtained from about 15,000 of the 191,000 intermediate systems in the North Central and from about 46,000 of the 391,000 intermediate systems in the South.) In the West, about 85 percent of the responding systems (about 45,000 responded out of a total of 119,000) reported that all of the tests had shown acceptable results, 8 percent of the systems reported that nearly all tests (92 percent) had acceptable results, and 7 percent of the systems (about 3,000) reported that only a few passed (17 percent of the year's tests). In the Northeast, 11.7 percent of responding systems (41,000 responded out of a total of 144,000) reported that half the tests or fewer had shown acceptable results. In fact, 8.7 percent of systems (about 4,000) reported that all bacteriological tests had unacceptable results.

— Chemical and physical water quality tests

National data showed that only 9.7 percent of all intermediate systems performed chemical water quality tests of any kind. Regional variation in this proportion was considerable, however (see Table VII-70). The Northeast had the greatest proportion of intermediate systems performing chemical tests (23.9

Table VII-70

Regional Variation in Performance of Chemical and Physical Water Quality Tests Among Intermediate Systems

	Number and Percent of Systems			
	Northeast	North Central	South	West
Tests not performed	106,000 73.4%	169,000 88.7%	346,000 88.7%	81,000 67.8%
Tests performed	34,000 23.9%	9,000 4.6%	23,000 5.8%	16,000 13.3%
Could not be determined	4,000 2.7%	13,000 6.7%	22,000 5.5%	23,000 18.9%
Total	144,000 100.0%	191,000 100.0%	391,000 100.0%	119,000 100.0%
Date of most recent test				
1975 or earlier	15,000 44.8%*	2,000 26.1%	3,000 14.0%	8,000 52.1%
1976	2,000 6.0%	0 0.0%	10,000 45.8%	900 5.7%
1977	4,000 13.0%	2,000 27.1%	2,000 8.8%	0 0.0%
1978	12,000 36.3%	2,000 22.4%	7,000 31.4%	5,000 28.8%
Could not be determined	0 0.0%	2,000 24.4%	0 0.0%	2,000 13.4%
Total	34,000 100.1%	9,000 100.0%	23,000 100.0%	16,000 100.0%

*Percentages are based on the number of systems in each region which performed chemical or physical water quality tests.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

percent). In the West, the proportion was 13.3 percent, compared to 5.8 percent in the South and 4.6 percent in the North Central. (Interestingly, proportionately more systems in the Northeast assayed for chemical and physical content, while proportionately more systems in the West did bacteriological tests.)

In the Northeast and North Central, almost half of the systems that performed chemical tests had done so within approximately one year of the NSA survey (in 1977 or 1978). Chemical water quality tests had been performed in 1977 or 1978 at about 40 percent of the systems that did testing in the South, and at about 29 percent of those that tested in the West (see Table VII-70).

Because data on chemical and physical water quality tests were severely limited, no test results are presented.

SMSA/nonSMSA variation in general reference features of intermediate systems

Most intermediate systems—about 78 percent, or 658,000—were located outside of SMSAs. About 22 percent, or 187,000 systems, were located within SMSAs. Two-connection intermediate systems were by far the most common both inside and outside SMSAs. They made up 80.1 percent of intermediate systems within SMSAs and 75.3 percent of intermediate systems outside SMSAs. Three-connection systems made up 9.2 percent of the intermediate systems within SMSAs and 16.3 percent outside SMSAs. Within SMSAs, 10.6 percent of intermediate systems (20,000) were composed of four through fourteen connections; outside SMSAs, the proportion was 8.4 percent (55,000 systems).

Very few intermediate systems metered their connections for water usage, whether inside or outside of SMSAs.

Most intermediate systems, whether located inside or outside SMSAs, had only one kilometer or less of distribution lines. However, proportionately more SMSA systems had from two through ten kilometers, or 1.2 to six miles, of lines (12.5 percent, compared to 3.1 percent among nonSMSA systems). Systems with more extensive distribution lines were slightly more prevalent outside SMSAs than inside (4.4 percent, compared to 1.1 percent).

There was little difference between SMSA and nonSMSA intermediate systems with regard to the sources of water they used, except that a small proportion of nonSMSA systems (about 53,000) used multiple sources, while no SMSA systems did.

Little variation was evident in the proportions of SMSA and nonSMSA systems that had relatively common forms of ownership, though nonSMSA systems showed a wider variety of forms of ownership, including tribal ownership.

As to age, nonSMSA systems tended to be newer. (Age was defined in the NSA as the number of years since original construction or since the last major alteration to the system.) The median age of nonSMSA systems was 6.4 years, compared to a median age of 9.7 years among SMSA systems. Only 12.7 percent of nonSMSA systems were over twenty years old, compared to 28.0 percent of SMSA systems. However, the median age of both SMSA and nonSMSA systems was well below twenty years, an age which has been associated with greater likelihood for equipment problems. Table VII-71 presents the full comparison of the ages of SMSA and nonSMSA systems.

Few intermediate systems could supply information on average daily use or design capacity. With regard to average daily use, the median quantity reported among SMSA systems was 392 liters (about 103 gallons), while among nonSMSA systems the median was 758 liters (about 200 gallons). However, these figures are based on data from only about 28 percent of SMSA systems and 18 percent of nonSMSA systems. Design capacity showed a median of 65,550 liters (17,305 gallons) among SMSA systems and a median of 43,661 liters (11,526 gallons) among nonSMSA systems, but the medians were based on information from only about 20 percent of systems. Complete data are presented in Table VII-72.

Table VII-71

SMSA/NonSMSA Variation in Age of Intermediate Systems

Age (Number of Years Since Construction or Alteration)	Number and Percent of Systems SMSA	Number and Percent of Systems NonSMSA
Less than 1 year	4,000 1.9%	42,000 6.5%
1 - 5 years	50,000 26.9%	232,000 35.2%
6 - 10 years	35,000 18.7%	139,000 21.1%
11 - 20 years	28,000 15.0%	130,000 19.7%
21 - 50 years	38,000 20.1%	72,000 10.9%
More than 50	15,000 7.9%	12,000 1.8%
Continuous improvements	0 0.0%	2,000 0.2%
Could not be determined	18,000 9.5%	30,000 4.6%
Total	187,000 100.0%	658,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-72

SMSA/NonSMSA Variation in Average Daily Use and Maximum Daily Design Capacity for Intermediate Systems

Quantity in Liters	Approximate Quantity in Gallons	Number and Percent of Systems	
		SMSA	NonSMSA
Average Daily Use			
1 - 500	132 or less	26,000 14.2%	50,000 7.6%
501 - 1,000	133 - 264	6,000 3.4%	20,000 3.0%
1,001 - 5,000	265 - 1,320	10,000 5.6%	43,000 6.5%
More than 5,000	More than 1,321	8,000 4.5%	4,000 0.6%
Could not be determined		134,000 72.3%	541,000 82.3%
Total		185,000 100.0%	658,000 100.0%
Maximum Daily Design Capacity			
1 - 25,000	6,604 or less	9,000 4.6%	53,000 8.0%
25,001 - 50,000	6,605 - 13,208	9,000 4.6%	24,000 3.6%
50,001 - 100,000	13,209 - 26,417	3,000 1.4%	25,000 3.9%
100,001 - 500,000	26,418 - 132,086	16,000 8.4%	30,000 4.5%
More than 500,000	More than 132,086	2,000 1.1%	10,000 1.6%
Could not be determined		149,000 79.9%	516,000 78.4%
Total		185,000 100.0%	658,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

SMSA/nonSMSA variation in external engineering features of intermediate systems

Differences with regard to engineering features of intermediate wells and springs are presented in this section, but there were too few intermediate systems using surface water and precipitation to allow subnational comparisons about these systems.

SMSA/nonSMSA distribution of intermediate system wells and springs

Since most intermediate systems used wells, the distribution of intermediate wells closely mirrored the distribution of intermediate systems of all kinds. Specifically, 75.9 percent of intermediate wells (565,000) were located outside of SMSAs, and 24.1 percent (180,000) were located within SMSAs. As for springs, 93 percent were located outside SMSAs, and 7 percent (about 5,000 systems) were located inside SMSAs.

SMSA/nonSMSA variation in sites of intermediate system wellheads

A greater proportion of nonSMSA intermediate wells terminated above ground, but there was virtually no difference in the proportion of SMSA and nonSMSA wells that were completely uncovered (see Table VII-73). Well pits were found more frequently among SMSA wells than among nonSMSA wells, and generally they were not equipped with watertight covers. Buried wellheads—another unsatisfactory arrangement—also were proportionately more common among SMSA wells (15.9 percent, compared to 10.7 percent among nonSMSA wells).

SMSA/nonSMSA variation in construction of intermediate system wells

Well construction seemed very much the same inside and outside SMSAs, except that bored wells were more common outside of SMSAs (10.0 percent of intermediate wells, compared to 4.9 percent of intermediate wells within SMSAs). The great majority of intermediate wells, both inside and outside SMSAs, were

Table VII-73

SMSA/NonSMSA Variation in Wellhead Arrangements for Intermediate System Wells

Classification	Number and Percent of Systems SMSA	 NonSMSA
Terminated above ground		
Protected by shed, roof,	83,000 46.1%	317,000 56.1%
Uncovered	28,000 15.3%	78,000 13.7%
Subtotal	111,000 61.4%	395,000 69.8%
Situated in well pit		
Pit without watertight cover	25,000 14.1%	20,000 3.5%
Pit with watertight cover	4,000 2.4%	37,000 6.5%
Subtotal	30,000 16.5%	57,000 10.0%
Buried	29,000 15.9%	60,000 10.7%
Situated in household	3,000 1.8%	18,000 3.3%
Miscellaneous arrangements	800 0.5%	9,000 1.6%
Arrangements could not be determined	7,000 3.9%	26,000 4.6%
Total	180,000 100.0%	565,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

drilled (see Table VII-74). Estimates given for SMSA wells may be low, however, because information about construction type was not available for about 20 percent of SMSA wells.

SMSA/nonSMSA variation in age of intermediate system wells

Intermediate wells within SMSAs tended to be newer than those located outside of SMSAs, despite the fact that when all kinds of intermediate systems were considered, SMSA systems were found to be older. The median age of SMSA wells was seven years, and the median age of nonSMSA wells was eleven years. From the complete age tabulation (see Table VII-75), it can be seen that proportionately more SMSA intermediate wells were ten years old or less (56.6 percent, compared to 42.0 percent among nonSMSA intermediate wells). Conversely, proportionately more nonSMSA intermediate wells were from eleven to twenty years old (24.0 percent, compared to 9.0 percent among SMSA intermediate wells). An EPA survey has indicated an increased risk of contamination among wells more than twenty years old; such wells were slightly more common inside SMSAs than outside SMSAs (22.9 percent and 18.7 percent, respectively).

SMSA/nonSMSA variation in depth of intermediate system wells

On the average, SMSA wells were deeper than nonSMSA wells. The median depth for SMSA wells was 38.2 meters (about 125 feet); for nonSMSA wells, it was 29.8 meters (about 98 feet). Relatively few intermediate wells were less than ten feet deep, a minimum depth recommended by EPA, but all 11,000 were located outside SMSAs.

Table VII-74

SMSA/NonSMSA Variation in Construction of Intermediate System Wells

	Number and Percent of Systems	
Type of Construction	SMSA	NonSMSA
Drilled	113,000 62.6%	368,000 65.1%
Bored	9,000 4.9%	57,000 10.0%
Dug	16,000 8.7%	46,000 8.2%
Driven	5,000 2.6%	18,000 3.1%
Jetted	2,000 1.3%	13,000 2.4%
Could not be determined	36,000 19.9%	63,000 11.2%
Total	180,000 100.0%	565,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-75

SMSA/NonSMSA Variation in Age of Intermediate System Wells

Age (Number of Years Since Construction or Alteration)	Number and Percent of Systems	
	SMSA	NonSMSA
5 or less	69,000 38.4%	167,000 29.6%
6 - 10	33,000 18.2%	70,000 12.4%
11 - 15	13,000 7.1%	81,000 14.4%
16 - 20	3,000 1.9%	54,000 9.6%
21 - 50	29,000 16.1%	89,000 15.7%
More than 50 years	12,000 6.8%	17,000 3.0%
Could not be determined	21,000 11.5%	87,000 15.4%
Total	180,000 100.0%	565,000 100.1%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

SMSA/nonSMSA variation in casing diameter for intermediate system wells

No difference was detected in median estimates of casing diameters inside and outside SMSAs. The median casing diameter for both groups of intermediate wells was 15.2 centimeters, or six inches.

SMSA/nonSMSA variation in grouting of intermediate system wells

Approximately equal proportions of wells inside and outside SMSAs were known to have grouting (32.7 percent of SMSA wells and 35.8 percent of nonSMSA wells). More intermediate wells outside of SMSAs were known not to have grouting (42.0 percent, compared to 32.0 percent of SMSA wells). However, information about grouting was unavailable for large proportions of intermediate wells—35.3 percent of SMSA wells and 22.2 percent of nonSMSA wells—and the findings must be interpreted cautiously.

SMSA/nonSMSA variation in wellhead sealing against pollutants

There was little variation from national findings as to the general acceptability of well covers or with regard to whether the cover was splashproof; nor did SMSA and nonSMSA intermediate wells differ with regard to the adequacy of source protection. Likewise, the combined evaluation of wellhead sealing showed little variation from national estimates. The proportions acceptable on all three factors were 63.5 percent, SMSA, and 67.8 percent, nonSMSA. Unacceptable on one factor were 6.1 percent of SMSA wells and 6.5 percent of nonSMSA wells. Unacceptable on two factors were 10.4 percent of SMSA wells and 5.1 percent of nonSMSA wells. Unacceptable on all three factors were 7.3 percent of SMSA wells and 10.6 percent of nonSMSA wells.

SMSA/nonSMSA variation in distance to potential pollution sources for intermediate system wells

NSA interviewers measured the distance between intermediate wells and potential sources of pollution. Presented in Table VII-76 are the proportions of SMSA and nonSMSA intermediate wells which were within sixteen meters (about 50 feet, the distance recommended by EPA) of various potential pollution sources. For 22.0 percent of SMSA intermediate wells, and for 14.0 percent of nonSMSA intermediate wells, sewage disposal systems had been sited too near the well. Fuel tanks were situated too close to 16.0 percent of nonSMSA wells and 8.0 percent of SMSA wells. Animal waste was observed within 50 feet of 13.1 percent of SMSA intermediate wells and 7.9 percent of nonSMSA intermediate wells. Other potential sources of pollution also were observed, but for smaller proportions of wells, as shown in Table VII-76.

SMSA/nonSMSA variation in access to well equipment (pitless adapter, buried seal)

Pitless adapters were present in 18.5 percent of intermediate wells outside of SMSAs, and in 9.9 percent of those inside SMSAs. Buried seals, which are undesirable because they inhibit routine maintenance and testing, were present in 21.2 percent of SMSA wells and 11.5 percent of nonSMSA wells. By far the most common well configuration was to have neither a buried seal nor pitless adapter, however: 59.2 percent of intermediate system wells outside of SMSAs and 50.4 percent of those inside SMSAs had neither. (This was not necessarily an undesirable situation, since many wells are constructed without a need for either type of equipment.) It could not be determined whether pitless adapters or buried seals were present in 18.5 percent of SMSA systems and 10.8 percent of nonSMSA systems.

Table VII-76

SMSA/NonSMSA Variation in Intermediate System Wells Within Sixteen Meters of Potential Pollution Sources

Type of Pollution Source	Number and Percent of Systems*	
	SMSA	NonSMSA
Sewage disposal system	40,000 22.0%	79,000 14.0%
Oil or gasoline tank	14,000 8.0%	91,000 16.0%
Animal waste	23,000 13.1%	45,000 7.9%
Agricultural fertilizer or runoff	14,000 7.4%	32,000 5.6%
Surface water contamination (such as pond, lake, or river which might flood into well)	11,000 5.9%	23,000 4.0%
Highway salt	**	12,000 2.1%
Industrial Waste	5,000 2.3%	20,000 3.5%
Other contamination	1,000 0.6%	17,000 3.1%
Total Systems	180,000	565,000

*Percentages are based on the number of intermediate system wells in each grouping.

**Indicates that source of contamination was not observed during inspection.

SMSA/nonSMSA variation in intrusion protection for intermediate system springs

Most intermediate system springs across the US were not adequately protected. In fact, of the 5,000 spring systems inside SMSAs, none had acceptable covers, and none had adequate source protection. Outside SMSAs, 72.9 percent of the 76,000 intermediate system springs had inadequate covers and 62.5 percent had inadequate source protection.

SMSA/nonSMSA variation in distance to potential pollution sources for intermediate system springs

The most striking finding with regard to potential pollution sources was that sewage disposal systems had been sited within 30 meters (100 feet) of almost two-thirds of intermediate system springs within SMSAs. This problem was rarely observed among intermediate springs outside of SMSAs. Surface water contamination was a potential problem for 37.2 percent of intermediate springs within SMSAs and for 22.0 percent of intermediate springs outside of SMSAs. Animal waste and other sources of potential contamination were observed within 30 meters of 12.8 percent and 9.4 percent, respectively, of intermediate springs outside of SMSAs, but at no systems within SMSAs. Table VII-77 presents all observations of potential pollution sources for SMSA and nonSMSA intermediate springs.

SMSA/nonSMSA variation in general system considerations for all intermediate systems

SMSA/nonSMSA variation in methods for water distribution

About 90 percent of intermediate systems across the US used electric pumps to supply the force necessary for water distribution, and the proportion was approximately the same for both SMSA and nonSMSA households. A slightly larger proportion of nonSMSA intermediate systems relied on gravity flow, however (6.0 percent, compared to 3.5 percent of SMSA intermediate systems). Only

Table VII-77

SMSA/NonSMSA Variation in Intermediate System Springs Within 30 Meters of Potential Pollution Sources

Type of Pollution Source	Number and Percent of Systems* SMSA	NonSMSA
Sewage disposal system	3,000 62.8%	2,000 2.4%
Oil or gasoline tank	0 0.0%	0 0.0%
Animal waste	0 0.0%	10,000 12.8%
Agricultural fertilizer or runoff	**	0 0.0%
Surface water contamination (such as pond, lake, or river which might flood into spring)	2,000 37.2%	17,000 22.0%
Highway salt	**	0 0.0%
Industrial waste	**	**
Other contamination	**	7,000 9.4%
Total Systems	5,000	76,000

*Percentages are based on the number of intermediate system springs in each grouping.

**Indicates that source of contamination was not observed during inspection.

intermediate systems located outside of SMSAs relied on artesian pressure (0.4 percent, or 3,000 systems).

SMSA/nonSMSA variation in water distribution and treatment devices

As explained earlier, original-construction equipment included essentials such as distribution lines and water sources. Pumps were the primary mode of conveyance, although a small proportion of systems used gravity flow and artesian pressure.

In addition to those items, original equipment included pressure tanks, storage tanks, reservoirs, and treatment facilities. Pressure tanks were originally installed at roughly 30 percent of nonSMSA systems, compared to 18 percent of SMSA systems. About equal proportions of SMSA and nonSMSA systems installed storage facilities and reservoirs at the time of construction, while only nonSMSA systems installed treatment facilities during original construction (5.3 percent).

In addition to obtaining information on treatment facilities installed during system construction, the NSA assessed the prevalence of specific treatment processes and devices among intermediate systems. The SMSA/nonSMSA comparison is presented in Table VII-78. (Treatment processes included any treatment conducted by the system on a regular basis; to be counted, a treatment device had to be in working order at the time of the NSA interview and had to be part of the system facilities.)

Approximately equal proportions of SMSA and nonSMSA intermediate systems performed various forms of water treatment—11.8 percent of SMSA systems and 9.6 percent of nonSMSA systems. In regard to specific kinds of water treatment, there was also little variation between SMSA and nonSMSA intermediate systems (see Table VII-78). Slightly greater proportions of SMSA systems normally treated the water by filtering and softening, but working softeners were

Table VII-78

SMSA/NonSMSA Variation in Water Treatment Processes and Devices Among Intermediate Systems

Characteristic	Number and Percent of Systems* SMSA	NonSMSA
Treatment Processes		
Filtration	11,000 5.6%	14,000 2.1%
Softening	16,000 8.4%	35,000 5.4%
Chlorination	5,000 2.8%	19,000 2.8%
Other treatment	0 0.0%	6,000 0.9%
Treatment Devices		
Activated carbon or anthracite filter	800 0.4%	7,000 1.1%
Softener	9,000 4.6%	39,000 5.9%
Chlorinator	4,000 2.1%	11,000 1.6%
Miscellaneous filter	3,000 1.4%	13,000 1.9%
Other devices	0 0.0%	5,000 0.8%
Total Systems	187,000	658,000

*Table reports systems having at least one treatment process or device.

actually in place at a greater proportion of nonSMSA systems. Other SMSA/nonSMSA differences were inconsequential.

SMSA/nonSMSA variation in intermediate system operators

Little variation was evident in the number of operators used by intermediate systems inside and outside SMSAs, except that a greater proportion of SMSA systems reported having no operator, and a greater proportion of nonSMSA systems reported having one operator (see Table VII-79). The difference, which amounted to about six percentage points, indicated that proportionally more SMSA systems functioned without any operator (about 40 percent, compared to about 34 percent of nonSMSA intermediate systems).

Data on the status of intermediate system operators indicated a greater tendency for nonSMSA systems to have paid, part-time employees instead of relying on volunteer labor (see Table VII-79). Paid, part-time workers were employed at 11.0 percent of nonSMSA intermediate systems, compared to 6.2 percent of SMSA intermediate systems. Labor for the great majority of intermediate systems—91.2 percent within SMSAs and 82.8 percent outside of SMSAs—was provided on a volunteer basis. As for special training, there was no difference between SMSA and nonSMSA system operators.

Overall, intermediate systems' labor requirements were small, amounting to one man-day per month or less. No differences were seen in this regard between SMSA and nonSMSA systems.

SMSA/nonSMSA variation in system performance

Most intermediate systems had experienced few breakdowns in the year prior to the NSA. Among SMSA systems, 80.7 had none at all, and 12.1 percent had one. Among nonSMSA systems, 72.5 percent had no breakdowns, and 17.7 percent had one. Proportions of systems that had experienced two or more breakdowns

Table VII-79

SMSA/NonSMSA Variation in Number and Work Status of Operators of Intermediate Systems

Characteristic	Number and Percent of Systems	
	SMSA	NonSMSA
Number of Operators		
0	74,000 39.8%	225,000 34.1%
1	81,000 43.2%	332,000 50.4%
2	23,000 12.1%	74,000 11.3%
3 - 5	5,000 2.6%	25,000 3.8%
Could not be determined	4,000 2.3%	3,000 0.4%
Total Systems	187,000 100.0%	658,000 100.0%
Status of Operators*		
Volunteer	103,000 91.2%	359,000 82.8%
Paid part-time	7,000 6.2%	48,000 11.0%
Paid full-time	400 0.4%	8,000 1.9%
Could not be determined	4,000 3.5%	21,000 4.7%
Total Systems	113,000	433,000

*Percentages (status of operators) are based on the number of systems in each grouping which had operators; percentages do not add to 100 percent because, for example, some systems may have used both full-time and part-time operators.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

were about equal, but the maximum number of breakdowns among nonSMSA systems was fifteen. By comparison, some SMSA systems had more than 95 breakdowns during the year prior to the NSA, indicating continuous problems that were not resolved.

Though system breakdowns do not necessarily imply a loss of service to water users, most breakdowns among intermediate systems apparently had caused loss of service. Among SMSA intermediate systems, 19.3 percent had experienced at least one breakdown, and about 16 percent reported that a breakdown had resulted in a loss of service to users. Among nonSMSA intermediate systems, 27.5 percent had experienced breakdowns and nearly 25 percent reported a loss of service to users.

The reasons for system breakdowns showed substantial variation between SMSA and nonSMSA systems, as shown in Table VII-80. Pump malfunctions were the most frequent cause of system breakdowns among SMSA systems (59.7 percent of the intermediate systems reporting breakdowns), but were the cause of breakdowns at only 41.1 percent of the nonSMSA systems. Ruptured lines, also a common cause of breakdowns, occurred more frequently among nonSMSA systems (43.0 percent) than among SMSA systems (31.9 percent). Power failures caused system breakdowns at 9.1 percent of nonSMSA systems, but at only 3.5 percent of SMSA systems. Interestingly, drought, flooding, vandalism, and treatment equipment failure caused system breakdowns almost exclusively among SMSA systems.

The second aspect of system performance that was assessed in the NSA was the difficulty a system had in obtaining water from the source. There was essentially no difference between SMSA and nonSMSA intermediate systems in the frequency of obtaining water from a groundwater source, or in the reasons for the difficulties (see Table VII-81). About 94 percent of both SMSA and nonSMSA systems had no difficulties with groundwater sources. Equipment breakdowns were

Table VII-80

SMSA/NonSMSA Variation in the Frequency and Reasons for Breakdowns in Intermediate Systems

Characteristic	Number and Percent of Systems	
	SMSA	NonSMSA
Number of Breakdowns During Previous Year		
0	151,000 80.7%	477,000 72.5%
1	23,000 12.1%	116,000 17.7%
2 or more	13,000 7.2%	65,000 9.8%
Maximum	95	15
Total	187,000 100.0%	658,000 100.0%
Reasons for Breakdowns		
Pump malfunction	22,000 59.7%	74,000 41.1%
Ruptured lines	12,000 31.9%	78,000 43.0%
Power failure	1,000 3.5%	16,000 9.1%
Drought	2,000 4.7%	700 0.4%
Flooding	2,000 4.7%	0 0.0%
Vandalism	2,000 4.7%	0 0.0%
Treatment failure	1,000 3.0%	0 0.0%
Other reasons	4,000 10.9%	19,000 10.5%
*Total Systems with Breakdowns	36,000	181,000

*Percentages do not add to 100 percent because, for example, some systems may have reported multiple reasons.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

the most common type of difficulty, reported by 3.8 percent of SMSA systems and 3.2 percent of nonSMSA systems.

Much greater proportions of intermediate systems using surface water experienced difficulties in acquiring water from the source. As shown in Table VII-81, 86.2 percent of SMSA systems and 78.1 percent of nonSMSA systems reported no difficulties. The most prominent problems for systems using surface water sources were related to weather conditions, which caused difficulties for 6.5 percent of nonSMSA systems and for 13.9 percent of SMSA systems. (Weather was the only problem for intermediate SMSA systems using surface water.) Contamination was a problem for 10.9 percent of nonSMSA systems using surface water, and other sorts of problems also were reported. (There were fewer intermediate systems using surface water than groundwater, however, so the number of affected systems was lower.)

SMSA/nonSMSA variation in intermediate system water test history

— Bacteriological water quality tests

About 22 percent of both SMSA and nonSMSA intermediate systems conducted bacteriological tests for water quality. However, as can be seen from Table VII-82, the great majority of those systems performing tests did so on an irregular basis, or did so only once a year or less often. Only 16.8 percent of the SMSA systems that performed testing did so more often than once a year. This amounted to some 7,000 systems out of a total of 187,000 intermediate systems within SMSAs. Likewise, only 12.1 percent of the nonSMSA systems that performed testing did so more often than once a year. This percentage amounted to roughly 18,000 out of a total of 658,000 intermediate systems outside of SMSAs.

SMSA and nonSMSA systems that performed testing differed as to the agencies that conducted the tests (see Table VII-82). Among SMSA systems, tests were chiefly conducted primarily by public health departments (59.5 percent),

Table VII-81

SMSA/NonSMSA Variation in Difficulties in Acquiring Water for Intermediate Systems Using Groundwater and Surface Water

Type of Difficulty	Number and Percent of Systems	
	SMSA	NonSMSA
Groundwater		
No difficulties	165,000 94.6%	566,000 93.8%
Equipment breakdowns	7,000 3.8%	19,000 3.2%
Water was unavailable	3,000 1.6%	10,000 1.6%
Weather problems	0 0.0%	9,000 1.6%
Loss of a supply	0 0.0%	3,000 0.5%
*Total	175,000	603,000
Surface water		
No difficulties	11,000 86.2%	45,000 78.1%
Equipment breakdowns	0 0.0%	2,000 4.3%
Water was unavailable	0 0.0%	3,000 5.2%
Weather problems	2,000 13.9%	4,000 6.5%
Contamination	0 0.0%	6,000 10.9%
*Total	12,000	57,000

*Totals reflect the number of systems supplied by each source. Percentages do not add to 100 percent because, for example, some systems may have reported more than one difficulty.

Table VII-82

SMSA/NonSMSA Variation in Frequency of Bacteriological Water Quality Tests Among Intermediate Systems, and Organizations Conducting the Tests

	Number and Percent of Systems*	
	SMSA	NonSMSA
Frequency of tests		
Not performed regularly	8,000 20.3%	22,000 14.9%
Once a year or less	26,000 62.9%	89,000 60.1%
At least once every six months	3,000 7.1%	6,000 4.2%
At least once every three months	4,000 9.0%	4,000 2.4%
At least once every month	0 0.0%	6,000 4.2%
At least once a week	300 0.7%	2,000 1.3%
Could not be determined	0 0.0%	19,000 12.9%
Total	41,000 100.0%	149,000 100.0%

Table VII-82 continued

	Number and Percent of Systems*	
	SMSA	Non SMSA
Organization conducting tests		
Public health department	24,000 59.5%	74,000 49.7%
Private laboratory	9,000 22.2%	16,000 10.5%
State environmental department	3,000 6.8%	20,000 13.6%
Federal laboratory	0 0.0%	7,000 4.5%
Hospital laboratory	0 0.0%	4,000 2.5%
Public health department and private laboratory	1,000 3.0%	0 0.0%
System laboratory	300 0.7%	0 0.0%
Other	1,000 2.6%	11,000 7.5%
Could not be determined	2,000 5.2%	17,000 11.7%
Total	41,000 100.0%	149,000 100.0%

*Table includes only those intermediate systems which reported conducting bacteriological water quality tests.

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private laboratories (22.2 percent), and state environmental departments (6.8 percent). Among nonSMSA systems that did testing, tests were conducted less often but still primarily by public health departments (49.7 percent), as well as by state environmental departments (13.6 percent), private laboratories (10.5 percent), and other agencies.

All intermediate systems within SMSAs which could provide test results (35,000 systems out of a total of 187,000) reported that all the tests performed in the year preceding the NSA had passed according to relevant standards. Among nonSMSA systems that could provide results (114,000 systems out of a total of 658,000), 92.9 percent had received generally acceptable test results (that is, at least 92 percent of the tests had passed); however, for 8,000 nonSMSA systems (7.1 percent), half or fewer of the tests taken during the previous year had shown acceptable results.

— Chemical and physical water quality tests

Chemical and physical water quality testing was even less common than bacteriological testing among intermediate systems. In the SMSA/nonSMSA comparison, the proportion of SMSA systems that sometimes performed chemical water quality tests was higher than the proportion for nonSMSA systems (13.0 percent versus 8.7 percent). Of the systems that performed tests, however, proportionately more nonSMSA systems had performed tests within about a year of the NSA—that is, in either 1977 or 1978 (see Table VII-83). Specifically, 50.9 percent of the nonSMSA intermediate systems had performed chemical tests in 1977 or 1978, compared to 23.9 percent of SMSA intermediate systems. These percentages amounted to very few systems: 29,000 out of a total of 658,000 nonSMSA intermediate systems, and 6,000 out of a total of 187,000 SMSA intermediate systems.

Table VII-83

SMSA/NonSMSA Variation in Performance of Chemical and Physical Water Quality Tests Among Intermediate Systems

	Number and Percent of Systems	
	SMSA	NonSMSA
Chemical or physical tests not performed	155,000 82.6%	548,000 83.3%
Chemical or physical tests performed	24,000 13.0%	57,000 8.7%
Could not be determined	8,000 4.5%	53,000 8.0%
Total	187,000 100.1%	658,000 100.0%
Date of most recent test		
1975 or earlier	5,000 20.7%*	24,000 42.0%
1976	9,000 37.7%	4,000 7.2%
1977	2,000 8.2%	7,000 12.0%
1978	4,000 15.7%	22,000 38.9%
Could not be determined	4,000 17.6%	0 0.0%
Total	24,000 99.9%	57,000 100.1%

*Percentages are based on the number of systems in each grouping which performed chemical or physical water quality tests.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Because data on chemical and physical water quality tests were severely limited, no test results are presented.

Size-of-place variation in general reference features of intermediate systems

Nearly all intermediate systems—95.6 percent, or 808,000—were not located in communities, but in other rural areas. Only 2.1 percent, or 18,000 systems, were located in large rural communities, and only 2.3 percent (20,000 systems) were located in small rural communities.

The size of intermediate systems showed substantial differences in the size-of-place comparison. Most systems had only two connections, but the proportions were quite different: 81.9 percent in large rural communities, 95.6 in small communities, and 75.8 percent in other rural areas. Three-connection systems comprised 18.1 percent of the intermediate systems in large rural communities and 15.0 percent of those in other rural areas, but the NSA sample included no three-connection systems in small rural communities. Systems having from four through fourteen connections were totally absent from large communities, but made up 4.4 percent of the intermediate systems in small communities and 9.1 percent of intermediate systems in other rural areas.

About 2 percent of intermediate systems in the US metered their connections to determine water usage levels, and no substantive variation was evident in the size-of-place comparison.

All intermediate systems in both large and small rural communities had one kilometer or less of distribution lines. In other rural areas, 78.4 percent had one kilometer or less of lines, 5.5 percent had from two through eight kilometers of lines, and 4.4 percent had from fifteen to 105 kilometers of service lines (that is, from nine through 63 miles).

Again, all intermediate systems in both large and small rural communities used groundwater exclusively. Among intermediate systems in other rural areas, 91.7 percent used groundwater, but 8.6 percent used surface water and 0.4 percent used purchased water.

Ownership of intermediate systems varied somewhat in the size-of-place comparison, mostly in the fact that other rural areas had a greater diversity of ownership. That is, all intermediate systems in large rural communities were owned by private individuals. In small rural communities, 95.6 percent were owned by private individuals, and 4.4 percent were owned by cooperatives, though probably of an informal nature. In other rural areas, too, private ownership predominated (90.6 percent of systems), but some systems were owned by cooperatives, some by private firms, and some by Indian tribes.

On the average, intermediate systems located in large rural communities were the newest and those located in other rural areas the oldest. The median age of systems located in large rural communities was only 1.8 years, while in small rural communities it was 3.4 years, and in other rural areas it was 7.3 years. The median age in each category was well below twenty years, which has been estimated as the average life expectancy of system equipment. None of the intermediate systems in large communities was known to be more than twenty years old, but the age of the system was unknown for 15.8 percent of the systems in large communities (see Table VII-84). Likewise, in small rural communities, only a small percentage of systems were known to be more than twenty years old, but age was unknown for 31.0 percent of systems. In other rural areas, 16.3 percent of systems were known to be more than twenty years old; this percentage amounted to approximately 132,000 systems.

Most intermediate systems were not able to provide information about average daily use or the design capacity of the system. For average daily use, information was unavailable for 100 percent of intermediate systems in large communities, and for about 80 percent of systems in small communities and other rural areas. As to the design capacity of the system, information was unavailable

Table VII-84

Size-of-Place Variation in Age of Intermediate Systems

Age (Number of Years Since Construction or Alteration)	Number and Percent of Systems		
	Large Rural Communities	Small Rural Communities	Other Rural Areas
Less than 1 year	0 0.0%	4,000 20.8%	42,000 5.2%
1 - 5 years	12,000 66.1%	4,000 21.8%	266,000 33.0%
6 - 10 years	0 0.0%	4,000 22.0%	169,000 20.9%
11 - 20 years	3,000 18.1%	0 0.0%	158,000 19.5%
21 - 50 years	0 0.0%	900 4.4%	105,000 13.0%
More than 50	0 0.0%	0 0.0%	27,000 3.3%
Continuous improvements	0 0.0%	0 0.0%	2,000 0.2%
Could not be determined	3,000 15.8%	6,000 31.0%	39,000 4.9%
Total	18,000 100.0%	20,000 100.0%	808,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

for about 68 percent of systems in large communities and for about 80 percent of systems in small communities and other rural areas. With this caveat, the median estimates for average daily use were 379 liters (about 100 gallons) in small rural communities, and 758 liters (about 200 gallons) in other rural areas. As for system design capacity, median estimates were about 21,830 liters (5,767 gallons) in large communities; 1,137 liters (about 300 gallons) in small communities; and 54,567 liters (14,415 gallons) in other rural areas. (The median estimate for systems in small communities was based on only 4,000 systems, about 29 percent of the intermediate systems in small rural communities.)

Size-of-place variation in external engineering features of intermediate systems

Data in this section give an indication of the differences in external engineering features of intermediate well systems and intermediate spring systems in large rural communities, small rural communities, and other rural areas. The structural features of intermediate cisterns and surface water supplies were not included in the size-of-place comparison because of the limitations of the data.

Size-of-place distribution of intermediate system wells and springs

Though the vast majority of intermediate systems everywhere used wells and springs, the proportions varied in places of different size. Intermediate systems in large rural communities used wells exclusively. In small rural communities, 78.0 percent of intermediate systems used wells and about 22 percent used springs. In other rural areas, 88.2 percent of intermediate systems used wells and 9.6 percent used springs. (Small proportions of intermediate systems in small communities and other rural areas used surface water supplies or cisterns, but they were not numerous enough to be subjected to a size-of-place comparison.)

Size-of-place variation in sites of intermediate system wellheads

Although the number of intermediate wells in large and small rural communities was small, the data seemed to indicate differences among wells in the three size-of-place categories (see Table VII-85). For instance, while 56.1 percent of intermediate wells in other rural areas terminated above ground but were protected in some way, none were sited like this in either large or small communities. Instead, large communities had intermediate wells that were situated within the household (48.0 percent), or in pits without watertight covers (33.9 percent). In small communities, 60.2 percent of intermediate wellheads were buried, and about 24 percent had various kinds of arrangements not otherwise common.

The two sorts of arrangements that were least desirable in terms of potential for contamination—wells that terminated above ground without adequate covering, and wells that were housed in pits without watertight covers—comprised 52.0 percent of intermediate wells in large communities. Such arrangements accounted for only 15.8 percent of intermediate wells in small communities and 19.5 percent of intermediate wells in other rural areas.

Size-of-place variation in construction of intermediate system wells

Drilled wells were the most prominent type everywhere, but comprised a greater proportion of intermediate wells in other rural areas (about 65 percent) than in either large or small rural communities (50.4 percent and 54.6 percent, respectively). As can be seen from Table VII-86, about one-third of intermediate wells in large rural communities were dug, compared to about 16 percent in small communities and about 8 percent in other rural areas. Bored wells and jetted wells among intermediate systems were found only in other rural areas. Driven wells were most commonly found in large rural communities (15.8 percent of intermediate wells there). (Information was not available for almost 30 percent of the

Table VII-85

Size-of-Place Variation in Wellhead Arrangements for Intermediate System Wells

	Number and Percent of Systems		
Classification	Large Rural Communities	Small Rural Communities	Other Rural Areas
Terminated above ground			
Protected by shed, roof, or other structure	0 0.0%	0 0.0%	400,000 56.1%
Uncovered	3,000 18.1%	2,000 15.8%	100,000 14.0%
Subtotal	3,000 18.1%	2,000 15.8%	500,000 70.1%
Situated in well pit			
Pit without watertight cover	6,000 33.9%	0 0.0%	39,000 5.5%
Pit with watertight cover	0 0.0%	0 0.0%	41,000 5.8%
Subtotal	6,000 33.9%	0 0.0%	80,000 11.3%
Buried	0 0.0%	9,000 60.2%	80,000 11.2%
Situated in household	8,000 48.0%	0 0.0%	13,000 1.8%
Miscellaneous arrangements	0 0.0%	4,000 23.9%	6,000 0.9%
Arrangements could not be determined	0 0.0%	0 0.0%	33,000 4.6%
Total	18,000 100.0%	20,000 99.9%	808,000 99.9%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-86

Size-of-Place Variation in Construction of Intermediate System Wells

Type of Construction	Number and Percent of Systems Large Rural Communities	 Small Rural Communities	 Other Rural Areas
Drilled	9,000 50.4%	8,000 54.6%	464,000 65.1%
Bored	0 0.0%	0 0.0%	60,000 8.4%
Dug	6,000 33.9%	2,000 15.8%	59,000 8.3%
Driven	3,000 15.8%	0 0.0%	20,000 2.8%
Jetted	0 0.0%	0 0.0%	16,000 2.2%
Could not be determined	0 0.0%	5,000 29.5%	95,000 13.3%
Total	18,000 100.1%	15,000 99.9%	712,000 100.1%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

intermediate wells in small communities, making estimates for well construction there less reliable.)

Size-of-place variation in age of intermediate system wells

Median ages indicated that intermediate wells tended to be older in small rural communities (about twelve years) than in large communities or other rural areas (nine years each). Small rural communities also had the highest proportion of intermediate wells that were more than twenty years old, an age associated with increased risk of contamination according to an EPA study.[24] As shown in Table VII-87, the proportion of wells over twenty years old was 23.9 percent in small rural communities, compared to 18.1 percent in large communities and 19.7 percent in other rural areas.

Size-of-place variation in depth of intermediate system wells

The average depth of intermediate wells varied considerably in the size-of-place comparison. Medians were 45.2 meters (about 148 feet) in small rural communities, 30.8 meters (about 100 feet) in other rural areas, and 24.2 meters (about 80 feet) in large rural communities.

According to the EPA, wells should be at least ten feet deep to provide an opportunity for water to be filtered as it percolates down through layers of soil.[25] In small rural communities, the NSA found no intermediate wells that were less than ten feet deep; in fact, none were less than 50 feet deep. In large rural communities, however, nearly 16 percent of intermediate wells were less than ten feet deep (this percentage amounted to about 3,000 wells). In other rural areas, 1.1 percent of intermediate wells were less than ten feet deep, which amounted to about 8,000 wells.

Table VII-87

Size-of-Place Variation in Age of Intermediate System Wells

Age (Number of Years Since Construction or Alteration)	Number and Percent of Systems		
	Large Rural Communities	Small Rural Communities	Other Rural Areas
5 or less	9,000 49.6%	4,000 28.0%	223,000 31.3%
6 - 10	0 0.0%	0 0.0%	103,000 14.4%
11 - 15	6,000 32.2%	4,000 26.7%	84,000 11.8%
16 - 20	0 0.0%	0 0.0%	58,000 8.1%
21 - 50	3,000 18.1%	0 0.0%	114,000 16.1%
More than 50	0 0.0%	4,000 23.9%	26,000 3.6%
Could not be determined	0 0.0%	3,000 21.4%	104,000 14.6%
Total	18,000 99.9%	15,000 100.0%	712,000 99.9%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Size-of-place variation in casing diameter for intermediate system wells

Intermediate wells in small rural communities had the smallest casings, on the average—the median was 5.1 centimeters (two inches), compared to 15.2 centimeters (six inches) in other rural areas and 14.4 centimeters (nearly six inches) in large rural communities.

Size-of-place variation in grouting of intermediate system wells

Grouting, which provides wells with a protection against contamination, was present in about 35 percent of intermediate wells in other rural areas and in about 34 percent of intermediate wells in large rural communities. The NSA found no intermediate wells that were grouted in small rural communities, but this was probably the result of so many systems lacking information about grouting (nearly 67 percent in small rural communities). Ungrouted wells amounted to about 48 percent of intermediate wells in large rural communities, about 40 percent in other rural areas, and about 33 percent in small rural communities. Information about grouting could not be provided for about 25 percent of intermediate wells in other rural areas and for about 18 percent of intermediate wells in large rural communities.

Size-of-place variation in wellhead sealing against pollutants

Wellhead sealing and source protection were assessed in terms of three factors—the general acceptability of the well cover, whether the cover was splashproof or not, and the adequacy of source protection (see Table VII-88). With regard to the first factor, all intermediate system wells had acceptable covers in large rural communities, but only about 84 percent did in small communities and 75.5 percent did in other rural areas. Well covers could be determined not to be splashproof in about equal proportions of intermediate system wells in each size-of-place category. On the other hand, 84.2 percent in large communities were

Table VII-88

Size-of-Place Variation in Adequacy of Wellhead Sealing and Source Protection in Intermediate System Wells

	Number and Percent of Systems		
Characteristic	Large Rural Communities	Small Rural Communities	Other Rural Areas
Cover (general acceptability)			
Acceptable	18,000 100.0%	13,000 84.2%	538,000 75.5%
Unacceptable	0 0.0%	2,000 15.8%	121,000 17.0%
Could not be determined	0 0.0%	0 0.0%	54,000 7.5%
Total	18,000 100.0%	15,000 100.0%	712,000 100.0%
Cover (splashproof or not)			
Splashproof	15,000 84.2%	9,000 57.5%	544,000 76.3%
Not splashproof	3,000 15.8%	2,000 15.8%	118,000 16.6%
Could not be determined	0 0.0%	4,000 26.7%	51,000 7.1%
Total	18,000 100.0%	15,000 100.0%	712,000 100.0%
Source protection			
Adequately protected	18,000 100.0%	15,000 100.0%	539,000 75.7%
Not adequately protected	0 0.0%	0 0.0%	120,000 16.9%
Could not be determined	0 0.0%	0 0.0%	53,000 7.4%
Total	18,000 100.0%	15,000 100.0%	712,000 100.0%

Table VII-88 continued

Characteristic	Number and Percent of Systems Large Rural Communities	Small Rural Communities	Other Rural Areas
Combined evaluation			
Acceptable on all three factors	15,000 84.2%	9,000 57.5%	474,000 66.5%
Unacceptable on one factor	3,000 15.8%	0 0.0%	45,000 6.3%
Unacceptable on two factors	0 0.0%	2,000 15.8%	45,000 6.3%
Unacceptable on all three factors	0 0.0%	0 0.0%	73,000 10.3%
Could not be determined	0 0.0%	4,000 26.7%	75,000 10.6%
Total	18,000 100.0%	15,000 100.0%	712,000 100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

determined to be splashproof, as were 57.5 percent in small communities and 76.3 percent in other rural areas. The condition of almost 27 percent of intermediate wells in small rural communities could not be determined, however, making that portion of the data less reliable.

All intermediate wells in both large and small rural communities were adequate with regard to source protection, as were 75.7 percent of those in other rural areas. Almost 17 percent in other rural areas were not adequately protected, however.

The combined evaluation (see Table VII-88) also suffered because of information being unavailable for so many wells in small rural communities. However, the largest proportion of wells that were acceptable with regard to all three factors occurred in large rural communities (84.2 percent), while the largest proportion unacceptable on all three factors occurred in other rural areas (10.3 percent).

Size-of-place variation in distance to potential pollution sources

NSA interviewers measured the distance between wells and various potential sources of pollution. Table VII-89 presents the proportions of intermediate wells which were within sixteen meters (about 50 feet, the distance recommended by EPA)[26] of various possible sources of pollution. Sewage disposal systems had apparently been sited too near to 43.8 percent of intermediate wells in small rural communities, to 18.1 percent of those in large rural communities, and to 15.3 percent in other rural areas. Fuel tanks were too close to about 16 percent of intermediate wells in large and small rural communities, and to 14.0 percent in other rural areas. Animal waste was observed within sixteen meters of 9.5 percent of intermediate wells in other rural areas, as were several other potential pollution sources, though for smaller proportions of wells. No potential pollution sources

Table VII-89

Size-of-Place Variation in Intermediate System Wells Within Sixteen Meters of Potential Pollution Sources

Type of Pollution Source	Number and Percent of Systems*		
	Large Rural Communities	Small Rural Communities	Other Rural Areas
Sewage disposal system	3,000 18.1%	7,000 43.8%	109,000 15.3%
Oil or gasoline tank	3,000 15.8%	2,000 15.8%	100,000 14.0%
Animal waste	**	0 0.0%	68,000 9.5%
Agricultural fertilizer	**	0 0.0%	45,000 6.3%
Surface water contamination (such as pond, lake, or river which might flood into well)	0 0.0%	**	33,000 4.7%
Highway salt	**	0 0.0%	12,000 1.7%
Industrial waste	**	0 0.0%	24,000 3.4%
Other contamination	**	**	18,000 2.6%
Total Systems	18,000	15,000	712,000

*Percentages are based on the number of intermediate system wells in each size-of-place grouping.

**Indicates that source of contamination was not observed during inspection.

besides sewage disposal systems and fuel tanks were observed within sixteen meters of intermediate wells in either large or small rural communities.

Size-of-place variation in access to well equipment (pitless adapter, buried seal)

There was wide variation with regard to the presence of pitless adapters in the size-of-place comparison (see Table VII-90). Pitless adapters were used in 18.1 percent of intermediate wells in large rural communities and in 16.7 percent of intermediate wells in other rural areas, but were not found in any intermediate wells in small rural communities. Buried seals, on the other hand, were present in 60.2 percent of intermediate wells in small communities and in 13.2 percent of intermediate wells in other rural areas, but were found in no intermediate wells in large rural communities. Large proportions of wells had neither pitless adapter nor buried seal (many wells are constructed without a need for such equipment).

Size-of-place variation in distribution of intermediate system springs

As discussed in the introduction to this section, most intermediate systems using springs were located in other rural areas (77,000); only 4,000 were located in small rural communities, and none were found in large rural communities. The data presented in the next two sections are therefore limited to small rural communities and other rural areas.

Size-of-place variation in intrusion protection for intermediate system springs

In general, intermediate springs had little or no protection against contamination. Either they had no cover at all, or covers were inadequate to protect against surface water entry and animal contamination. In small rural communities, no intermediate springs had adequate covers. In other rural areas, about 27 percent of intermediate springs had adequate covers, but 73 percent did not.

Table VII-90

Size-of-Place Variation in Use of Pitless Adapter and Buried Seal in Intermediate System Wells

	Number and Percent of Systems		
Well Equipment	Large Rural Communities	Small Rural Communities	Other Rural Areas
Pitless adapter	3,000	0	119,000
	18.1%	0.0%	16.7%
Buried seal	0	9,000	94,000
	0.0%	60.2%	13.2%
Neither	14,000	6,000	405,000
	81.9%	39.8%	56.8%
Could not be determined	0	0	94,000
	0.0%	0.0%	13.3%
Total	18,000	15,000	712,000
	100.0%	100.0%	100.0%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Also, none of the intermediate springs in small rural communities had adequate source protection. In other rural areas, about 37 percent did, but the rest did not.

Size-of-place variation in distance to potential pollution sources among intermediate system springs

Though safe distances from springs to potential sources of contamination are difficult to establish, a minimum distance of 30 meters (about 100 feet) was used for descriptive purposes in the NSA.

In small rural communities, all intermediate springs (about 4,000) were within 30 meters of a source of potential contamination from surface water that could flood into the spring. There were no sewage disposal systems within 30 meters of any of the springs, though they were, of course, present at greater distances. No other sources of potential pollution were observed within 30 meters of the springs.

In other rural areas, surface water contamination was a potential problem for 18.7 percent of intermediate springs (about 14,000). There was animal waste within 30 meters of 12.7 percent of intermediate springs (10,000), sewage disposal systems within 30 meters of 6.5 percent (5,000), and other potential sources of contamination within 30 meters of 9.3 percent (7,000). No intermediate springs in other rural areas were within 30 meters of fuel tanks, agricultural fertilizer or runoff, or highway salt, though such things were present at greater distances. Also, there was no observable industrial waste that posed any potential problem.

Size-of-place variation in general system considerations for all intermediate systems

Size-of-place variation in methods of water distribution in intermediate systems

Most intermediate systems used electric pumps for distributing water, but the proportions showed some variation. While all intermediate systems in large rural communities used electric pumps, the proportion in other rural areas was about 90 percent, and the proportion in small rural communities was only about 81 percent (though information was unavailable for the rest). In other rural areas, 5.7 percent of intermediate systems used gravity flow and 0.4 percent used artesian pressure, while the method of distribution could not be determined for 4.0 percent.

Size-of-place variation in water distribution and treatment devices

All intermediate systems required certain essential equipment such as distribution lines, water pumps (or, alternatively, gravity flow or artesian pressure), and water sources. Some systems, however, were more elaborate in construction, including various other devices.

In general, the more elaborate systems were located in large rural communities and other rural areas. For example, during original construction, all large-rural-community systems had installed storage facilities. In other rural areas, original installations included pressure tanks (28.3 percent), storage tanks (12.8 percent), and treatment facilities (4.2 percent). In contrast, no intermediate systems in small rural communities reported that pressure tanks, storage tanks, or treatment facilities had been installed at the time of construction.

As for water treatment equipment, data for intermediate systems in other rural areas were identical to national findings, since 96 percent of the systems were located in other rural areas and since no intermediate systems in either large or small communities used any water treatment equipment.

Size-of-place variation in intermediate system operators

Interesting operator differences existed among intermediate systems in large communities, small communities, and other rural areas (see Table VII-91). For example, in large rural communities, 50.4 percent of intermediate systems had no operators, and the rest had one paid, part-time operator. In small rural communities, 61.4 percent of intermediate systems had no operator, but 34.2 percent had one and 4.4 percent had two. Of the 7,900 systems in small communities that had operators, only about one-third used paid, part-time employees. In other rural areas, only 34.4 percent of intermediate systems had no operators. Of those that had operators, 86.2 percent used volunteer operators, 8.2 percent used part-time employees and 1.6 percent (about 9,000 systems) used paid full-time employees.

No intermediate systems in either large or small rural communities had operators who had undergone special training. In other rural areas, a very small proportion of intermediate systems (3 percent) used operators who had had special training.

Intermediate systems required little time in operation and maintenance. Systems in large and small communities generally required less than one man-day per month, and the same was true for intermediate systems in other rural areas. However, about 2 percent of the systems in other rural areas required two or more man-days per month for operation and maintenance.

Size-of-place variation in system performance

Generally, NSA data indicated that intermediate systems were fairly reliable, though some size-of-place variation existed in the number of breakdowns that they had had (see Table VII-92). Judging from the proportions of systems that had had no breakdowns in the year prior to the NSA survey, systems in other rural areas were the most reliable. In large communities, about 66 percent had

Table VII-91

Size-of-Place Variation in Number and Work Status of Operators of Intermediate Systems

Characteristic	Large Rural Communities	Small Rural Communities	Other Rural Areas
	Number and Percent of Systems		
Number of Operators			
0	9,000 50.4%	12,000 61.4%	278,000 34.4%
1	9,000 49.6%	7,000 34.2%	397,000 49.2%
2	0 0.0%	900 4.4%	96,000 11.9%
3 - 5	0 0.0%	0 0.0%	30,000 3.7%
Could not be determined	0 0.0%	0 0.0%	7,000 0.9%
Total Systems	18,000 100.0%	20,000 100.0%	808,000 100.1%
Status of Operators*			
Volunteer	0 0.0%	5,000 67.9%	457,000 86.2%
Paid part-time	9,000 100.0%	2,000 32.1%	44,000 8.2%
Paid full-time	0 0.0%	0 0.0%	9,000 1.6%
Could not be determined	0 0.0%	0 0.0%	25,000 4.7%
Total Systems	9,000	8,000	530,000

*Percentages (status of operators) are based on the number of systems in each grouping which had operators; percentages do not add to 100 percent because, for example, some systems may have used both full-time and part-time operators.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-92

Size-of-Place Variation in the Frequency and Reasons for Breakdowns in Intermediate Systems

	Number and Percent of Systems		
Characteristic	Large Rural Communities	Small Rural Communities	Other Rural Areas
Number of Breakdowns During Previous Year			
0	6,000 33.9%	11,000 57.2%	611,000 75.6%
1	6,000 33.9%	4,000 22.0%	129,000 15.9%
2 or more	6,000 32.2%	4,000 20.8%	68,000 8.5%
Maximum	2	2	95
Total	18,000 100.0%	20,000 100.0%	808,000 100.0%
Reasons for Breakdowns			
Pump malfunction	6,000 51.2%	4,000 51.4%	86,000 43.5%
Ruptured lines	0 0.0%	4,000 48.6%	85,000 43.2%
Power failure	6,000 48.8%	0 0.0%	12,000 6.1%
Drought	0 0.0%	0 0.0%	2,000 1.2%
Flooding	0 0.0%	0 0.0%	2,000 0.9%
Vandalism	0 0.0%	0 0.0%	2,000 0.9%
Treatment failure	0 0.0%	0 0.0%	1,000 0.5%
Other reasons	0 0.0%	0 0.0%	23,000 11.6%
*Total Systems with Breakdowns	12,000	8,000	197,000

*Percentages do not add to 100 percent because, for example, systems may have reported multiple reasons for breakdowns.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

experienced one or two breakdowns. In small rural communities, the proportion was 42.8 percent. In other rural areas, while only 24.4 percent of intermediate systems had experienced any breakdowns, some had experienced more than 95 during the year.

In large rural communities, breakdowns had been caused either by pump malfunctions or by power failures (see Table VII-92). In small rural communities, they had been caused either by pump malfunctions or ruptured lines. In other rural areas, pump malfunctions and ruptured lines accounted for most of the breakdowns, but a variety of other causes were also reported (chiefly power failures).

System performance also was evaluated in the NSA by the frequency of difficulties systems had in acquiring water from the source. Groundwater was, of course, the primary source of water for intermediate systems. In large rural communities, no intermediate system had experienced any difficulty in acquiring groundwater, but in small rural communities about 22 percent had. Difficulties were attributed equally to equipment breakdowns and weather problems. In other rural areas, about 6 percent of intermediate systems had difficulties acquiring groundwater, which were most often attributed to equipment breakdowns (2.9 percent of systems). A few systems in other rural areas reported that the difficulties were related to an occasional unavailability of the water supply (1.7 percent of systems), weather problems (less than 1 percent), and the loss of a supply (less than 1 percent).

No intermediate systems in either large or small rural communities relied on surface water. In other rural areas, of the 69,000 intermediate systems that used surface water either as a primary or secondary source of water, about 20 percent had experienced difficulties in acquiring it. Nearly half of the systems that reported difficulties said that the problem was related to contamination; for about 8 percent, weather conditions had caused the difficulty. Equipment breakdowns and water unavailability were also mentioned, but only infrequently.

Size-of-place variation in intermediate system water test history

— Bacteriological water quality tests

Bacteriological testing was never performed at the intermediate systems in large rural communities and was performed at only about 23 percent of those in small communities and other rural areas. Those that did test in small communities performed testing once a year or less often. In other rural areas, three out of every four that performed testing did so irregularly, or did so once a year or less often. About 5 percent of the systems that did testing in other rural areas—that is, about 9,000 systems—performed tests at least once every six months; 3.9 percent (about 7,000 systems) did testing once every three months; and 4.6 percent (about 8,000 systems) tested either monthly or weekly.

Intermediate systems in small rural communities relied exclusively on public health departments to conduct bacteriological tests. In other rural areas, public health departments performed the testing for 50.6 percent of the systems that did testing, while 13.4 percent of the systems used private laboratories and another 12.5 percent used state environmental departments. Small proportions of systems used federal laboratories or hospital laboratories (3.7 percent and 2.0 percent, respectively).

In small rural communities, all of the tests with known results had been acceptable. (Test results were available from about 4,000 out of a total of 20,000 systems in small communities.) Among systems in other rural areas, 91.9 percent of the systems that could provide test results reported that all of the tests had shown acceptable results, and another 2.5 percent of systems reported acceptable results on most tests. However, 5.5 percent, or about 8,000 systems, reported acceptable results on half or less of the tests conducted during the previous year. (Test results were available from 145,000 out of a total of 808,000 intermediate systems in other rural areas).

— Chemical and physical water quality tests

Overall, chemical water quality tests were performed by fewer systems than were bacteriological tests. This pattern did not hold, however, for intermediate systems in large rural communities. None of these systems performed any bacteriological tests, but 15.8 percent of them had performed chemical tests. This proportion was even larger than the proportion of intermediate systems in other rural areas that performed chemical tests (9.8 percent). In small rural communities, no intermediate system performed chemical tests.

About 44 percent of the intermediate systems in other rural areas that performed chemical testing had done such a test within about a year of the NSA survey (about 48,000 systems), and about half had performed chemical tests in 1976 or earlier. All the intermediate systems in large rural communities that performed testing reported that the most recent test was conducted in 1975 or earlier.

Because data on chemical and physical water quality tests were severely limited, no test results are presented.

COMMUNITY SYSTEMS

As pointed out earlier in this chapter, about the same number of rural households were served by community systems as by individual and intermediate systems combined. Yet, in terms of sheer numbers, the community systems (numbering 34,000) were overshadowed by individual systems (numbering 8,765,000) and even by intermediate systems (numbering 845,000). The reason for this disparity, of course, was that some of the community systems each served hundreds—even thousands—of households. In contrast, all of the individual systems each served only one household, and most of the intermediate systems served no more than three households.

As we have seen, the intermediate systems generally were no more completely equipped than the individual systems; in fact, they generally had less processing and treatment equipment. Ownership usually was with an individual, and the data conveyed the impression of informal business relationships (few systems had metered connections, for example). Although these conditions were facilitated by the nature of the intermediate systems, which were not much more complex than the individual systems, the same was not expected to be true for community systems. NSA investigators anticipated that the larger the community system, the more intricate would be its business, management, and technical makeup. This trend was historically evident in the development of water delivery systems, and it received new impetus with passage of the Safe Drinking Water Act. As discussed in Chapter II and Chapter V, the act mandated extensive water quality and monitoring programs for community-size systems ("community systems" in the NSA were roughly equivalent to the type which were regulated by the act).

In the NSA, community systems initially were defined as those which had fifteen or more service connections or which served more than 25 people (see question A-1, Appendix A). In this chapter, however, and in the NSA analysis generally, the definition is limited to systems which had fifteen or more service connections, since it was considered difficult for system representatives to report accurately on the number of people served by the systems.

The size (number of connections) is only one attribute of water systems, of course. That attribute is a convenient one for designating systems which are subject to specific legal requirements such as those initiated by the Safe Drinking Water Act, but it is not comprehensive enough for categorizing systems generally, even though in preceding sections of this report, discussions about systems have emphasized size based on the number of connections. Both the economic and physical configurations of systems, particularly of community systems, are more complex than can be conveyed by this one dimension, however. To illustrate, one community system may be an urban water utility which happens to supply water to rural households located on the periphery of its service area. Another community system of the same approximate size may consist of a conglomeration of discrete physical facilities that are operated and managed as a single administrative unit even though the system distributes water to rural households that are widely dispersed. While both systems may have the same number of connections, they probably have substantially different economic and technical aspects.

This situation complicated the interpretation of the NSA data. For example, interviewers were careful to obtain information from the system serving a particular rural household, but it was not always clear whether the information referred to one unified system or to a subunit of a conglomerate system. If the information referred to one unified, independent system—one serving a small rural community, for example—the information could be used to develop a profile for the entire system. If the information referred exclusively to one subunit of a conglomerate system, however, it could only produce a profile for that one segment of a complex system. The more frequent situation regarding a conglomerate system was that some of the information (the length of the distribution lines, for example) would refer exclusively to the subunit, but that other information (some of the financial information, for example) would refer to the system as a whole. Since confusion would result from mixing information about unified (or independent) systems with information about conglomerate (or consolidated) systems, it was decided that two classifications were needed for community systems.

To achieve this classification, community systems were grouped into two homogeneous categories according to whether there was correspondence between the systems' organizational and physical components. Community systems which were characterized by structures that reflected this correspondence were referred to as "independent systems," while those that were not were classified as "consolidated systems." An independent system was considered to be any independently administered entity which performed all functions associated with the provision of water. These functions included collection, treatment, and distribution, in addition to those activities which had to be accomplished to sustain the economic operation of the system, such as personnel recruitment and capital formation. More concretely, an independent system was one that secured water from its own source or sources, supported its own water processing, conditioning, and distribution facilities, and was directed by its own administrator or manager. Individuals occupying these supervisory and management positions could be autonomous, or they could be accountable to the mayor or city council of a rural municipality, or to the executive officer of some commercial enterprise or corporation. Similarly, the system did not necessarily have to be confined to a particular geographic locality as long as its primary service functions, such as billing and maintenance, were done by one central organization, and its facilities were physically integrated. Furthermore, the independent system could be composed of several subsystems which supplied water to other communities, provided that the facilities of each were physically incorporated into a broader service network that was centrally administered. Independent systems could be either publicly or privately owned, although the legal responsibilities of the principal administrator and the financial operation of the systems would probably vary accordingly.

In contrast to independent systems, consolidated systems possessed organizational structures which did not correspond exactly to the facilities that performed the physical functions necessary for water supply. These structures could either extend beyond the limits established by the physical arrangements, or they could be restricted to some portion of the complete aggregation of facilities. Given these distinguishing attributes, a consolidated system was designated as one of two basic types. The first was one in which the organizational apparatus was responsible for operating and managing a number of physically distinct sets of facilities, each of which conveyed water to its own user population. The second type was one in which several sets of facilities supported each other's operations, even though they were administered independently.

In the first type of consolidated system, one set of facilities could supply water to an unincorporated area of a county, even though another locality in the same county could obtain water from a different set of facilities. If these sets of facilities were jointly or centrally administered, the entire physical arrangement would be classified as a consolidated system even though its components were physically separate. Another example of the first type would be a conglomeration of facilities that conveyed water to various concentrations of rural residents in one particular area. Each collection of facilities might be located far enough apart to require local arrangements for supply, treatment, and maintenance, but they would be considered components of a consolidated system because their operation and management would be accomplished within the overall structure of a water district or similar administrative body. However, if these facilities were completely physically interconnected, the water district or water authority would be categorized as an independent system in the NSA.

Finally, the second type of consolidated system could be one in which one facility purchased finished or unfinished water from another organization to which its physical facilities were attached. In fact, because of this physical connection, both entities would be presumed to be part of the same consolidated system. In other words, consolidated systems develop the capability to perform the entire set of water supply functions only through a physical and organizational dependence on some other unit. Since it is impossible to determine with certainty which, if any, of these units accomplish the more critical function, all are considered to be constituents of the same system. The term "consolidated" acknowledges that these community systems consist of varying combinations of these physical and organizational elements that have been formally or informally integrated into one complete structure.

The classifications for community systems adopted by the NSA are compared to more conventional ones in Table VII-93. Although the table attempts to clarify the distinction between independent and consolidated systems, it should be used only as an idealized guide since the actual categorization process involved making an unprecedented judgment in the face of some very complex conditions. For example, one public system included in the NSA sample had grown substantially over the years by absorbing a number of smaller systems. The entire structure was operationally divided into several geographic regions or service areas, but it was administered as a single system. Since the facilities in one subsystem were usually connected with those of others, each could, if necessary, convey water that was extracted by another subsystem or impounded in its storage facilities. At least one subsystem of the overall operation, however, was completely autonomous in that it extracted water from its own wells and processed the water in its own treatment plant. From the perspective of the NSA, this system was difficult to classify because it had some characteristics that were normally associated with independent systems (physically connected, discrete subsystems within a single administrative structure) as well as other attributes which were more consistent with the definition of the first type of consolidated system (independent subsystems which were centrally administered). However, since the facilities of the system being considered were not completely integrated with each other, it was categorized as a consolidated system.

In assessing the NSA data on community water systems, it is necessary to recall that the information on independent systems is inherently more reliable than that for consolidated systems. As already explained, since the independent system was a single, unified operating unit that provided water to the household, the information compiled on the system generally referred to attributes or conditions that pertained to the entire entity. This was so whether the entity was a small

Table VII-93

Examples of Conventional Designations and NSA Categories of Community Systems

Conventional Designation	Operational Charactistics	NSA Category
Public Water Works within a Water District, Sanitary Commission, Water Improvement District, Utility District, Irrigation District, Water Authority, or other political body dealing with domestic water	Serves one individual community or rural area, but with substantial administrative, organizational, or physical links to other subsystems within the political body	One unit of a Consolidated System
Private Water Works	Serves one community or rural area, but owned and administered by a central company which jointly operates other, physically separated individual community facilities	One unit of a Consolidated System
Public Water Works (public ownership)	Serves one individual community or rural area; administrator or executive officer may be responsible to mayor, city manager, board or director of public utilities (water works may be part of combined utility), water commissioner, or other authority	Independent System
Private Water Works (private ownership)	Serves one individual community or rural area	Independent System
Public or Private Water Works	Purchases all of its supply water from another system	Consolidated System

system serving one rural community, or a very large urban system with facilities that extended out into a rural area.

Information for consolidated systems, on the other hand, occasionally referred to the complete entity, but the information sometimes instead referred only to the subsystem. The consolidated systems were potentially so complex that it was not feasible to determine whether the information was relevant to the entire system or only to some unspecified portion of it. As already noted, uncertainty about the reliability of the information about consolidated systems was the major factor in the decision to consider them separately from systems with the independent type of structure. By classifying community systems into these two groups, NSA researchers restricted the distortions in the data on community systems.

Despite these qualifications, a secondary advantage of the NSA categorization of community systems is that it provides an opportunity for some analysis of regionalization, a concept which is encouraged by the Safe Drinking Water Act. The act provides for an extension of the time allowed for compliance among systems which enter into "an enforceable agreement to become a part of a regional public water system."[27] For its part, the EPA views regionalization as one possible way for small systems to join together to meet the provisions of the act. Benefits of such regionalization might include operational advantages gained by centralized treatment and distribution, and administrative advantages gained by centralized management.[28] The possible gains in efficiency, as measured by economic factors, are a major consideration in weighing the benefits of regionalization.[29]

Actually, regionalization has come to mean two distinct concepts. The term "regionalization" itself generally refers to the physical interconnection of a number of systems and the sharing of certain common facilities such as treatment plants. The term "merger" generally denotes another concept; technically, it refers to the formal arrangement by which water system organizations are legally formed into a single body, but commonly it may refer to a less formal arrangement whereby some management or administrative functions among different systems are united. In the NSA, a merged system usually would be classified as consolidated, unless the merger also involved complete physical interconnection of the subunits, in which case the system could be classified as independent. A regionalized system, on the other hand, might be more likely to be classified as independent since regionalization usually implies complete physical interconnection among the subunits. As a result of the NSA categorization, then, the group of consolidated systems includes only those which would be roughly classified as either regionalized or merged. However, the consolidated category does not include all regionalized or merged systems since some with extensive physical interconnections would be categorized as independent systems.

The significance in this report is that the characteristics of systems in the NSA consolidated category shed some light on the nature of existing regionalized and merged systems in rural America. In this chapter, then, some of the organizational and physical characteristics of those systems are detailed. In Chapter VIII, some of their economic characteristics are investigated.

NSA analysis of community systems

In what follows, NSA data for independent and consolidated systems are considered separately. The discussion for each type of system generally follows the order used for the NSA report on intermediate systems. However, the details about supply-related engineering features which were considered for individual and intermediate systems are not addressed. Such an analysis for community systems would have been beyond the scope of the NSA, and it was not performed.

Development of the community system profile thus is not as complete as it was for individual and intermediate systems. That is, overall organizational and physical features—system size, miles of distribution pipes, source, ownership, age, water usage, capacity, and number of metered connections—are described first, but this discussion does not lead to a detailed report of supply engineering features. Instead, the discussion goes on to consider, in order, use of water distribution and treatment devices; the number, employment status, and experience of operators with the system; the availability (reliability and accessibility) of water within the system; and the history of water testing.

Finally, the previously discussed distortion in the data for consolidated systems was further magnified when the data were subdivided for analysis into regional, SMSA/nonSMSA, and size-of-place groupings. The distortion became particularly difficult because the case base from which projections were made became extremely small. In the regional analyses, for example, NSA interview information was available for less than 35 systems in each of the regions except the South, where information was available for 70 systems. The projections made from these small case bases were considered too unreliable for analysis, particularly because of the underlying uncertainties about whether the information referred to the entire system or only to some portion of it. In view of these problems, the NSA analysis was limited to findings for the nation as a whole. Subnational findings thus appear in this report only for independent systems.

Independent systems

Of the 34,000 community systems serving rural households, nearly nine of ten (a total of 30,000) were independent. The median number of independent-system connections was about 59. About 61 percent of the independent systems had fifteen through 100 connections; about 90 percent had fifteen through 500 connections. Only one system serving rural households had more than 100,000 connections. As a commentary note, no attempt was made in the NSA to distinguish between residential and commercial or industrial connections.

The size of community systems, as determined by number of connections, is a useful measure for describing the systems since it implies a number of organizational and economic features. However, it is difficult to put the NSA findings on system size into perspective at this point since there are no other studies with the same focus as the NSA. System size thus becomes more meaningful in the discussion of variation by size of place (later in this chapter), in the discussion of economic features of community systems (in Chapter VIII), and in the analysis of factors related to various water supply conditions.

In terms of length of distribution lines (including main lines but excluding service lines), many independent community systems had very limited distribution networks. In fact, 31.3 percent of all independent systems (a total of about 9,000) had only one kilometer (0.6 miles) or less of pipeline. An additional 37.1 percent (about 11,000) had from two through ten kilometers (1.24 through 6.2 miles) of pipeline, and 17.2 percent (about 5,000) had from eleven through 105 kilometers (6.8 through 65.2 miles) of pipeline. A further 4.2 percent of independent systems (about 1,000) had up to 10,000 kilometers (6,000 miles) of pipeline (0.2 percent actually had more than 10,000 kilometers, which was the limit of the NSA recording capacity). The information could not be obtained for 10.2 percent of systems (about 3,000). The median length was 2.4 kilometers (1.5 miles). In summary, about 68 percent of all independent community systems (approximately 21,000) had ten kilometers (6.2 miles) or less of pipeline. The majority of systems had three kilometers (1.9 miles) or less.

Source, ownership, and age of independent systems

Community systems commonly are described in overall terms of their source, ownership, and age, and data relevant to those characteristics are presented in Table VII-94. As to source, independent systems relied primarily on groundwater, as did individual and intermediate systems. Surface water was used

Table VII-94

Source, Ownership, and Age of Independent Community Systems

Characteristic	Nation Number of Systems	Nation Percent of Systems
Source		
Groundwater	27,000	90.2*
Surface water	3,000	11.5*
Ownership		
Public	11,000	36.8
Individual	9,000	31.4
Private firm	6,000	20.2
Cooperative	3,000	9.8
Indian tribe	200	0.8
Other	10	0.0
Could not be determined	300	0.9
Total	30,000	100.0
Age of system (number of years since construction or alteration)		
Less than 1	5,000	15.5
1 - 5	12,000	38.6
6 - 10	7,000	24.5
11 - 15	2,000	6.6
16 - 20	1,000	3.0
21 - 50	2,000	5.3
More than 50	200	0.9
Continuous improvements	800	2.6
Could not be determined	1,000	3.1
Total	30,000	100.1

*Some systems used both ground and surface water, so percentages total more than 100.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

considerably more often than in individual systems (1.1 percent of individual systems used surface water) and somewhat more often than in intermediate systems (8 percent of intermediate systems used surface water), but it still was used infrequently. About 500 independent community systems used both ground and surface sources. None used purchased water since by definition only consolidated community systems used that source.

Although the NSA findings about source were similar for the three types of systems, the findings about ownership were different. The independent community systems most often were owned by public bodies rather than by individuals, whereas individuals owned most of the individual and intermediate systems. As to other differences, the proportion of private firms owning independent community systems was more than ten times larger than the proportion owning individual or intermediate systems (see Tables VII-1 and VII-37 for comparisons). The proportion of cooperatives owning independent community systems was considerably larger than the proportion owning individual systems and somewhat larger than the proportion owning intermediate systems. In summary, the independent community systems tended to have a more complex, perhaps a more formal ownership arrangement. That is, two-thirds of the independent community systems were owned by the public, by private firms, or by cooperatives. In contrast, less than 10 percent of individual or intermediate systems had these arrangements—most were owned by private individuals.

The NSA approach to assessing system age for community systems was similar to that for intermediate systems, although different from that used for individual systems. The age of independent community systems (Table VII-94) was determined either by the number of years since original construction or by the number of years since subsequent major alteration of the systems. Median age was only three years—less than half the median age of intermediate systems. Furthermore, 78.6 percent of the community systems were ten years old or less, compared to 59.3 percent of intermediate systems. Although the independent community systems were younger, it must be emphasized that "age" in this situation was influenced either by time since original construction or by time since the last major alteration. A further complication was that at 2.6 percent of the systems (compared to 0.2 percent of intermediate systems), major alterations were so frequent that they were categorized as "continuous improvements." In terms of an indication of system age, such improvements created the equivalent of a system less than one year old, since the improvements had been continuing during the year of the NSA study.

Water usage, maximum design capacity, and metered connections

Two key operating characteristics of community systems, which also had organizational and economic implications, were the amount of water used (produced) each day and the design capacity of the system. The former characteristic provided a rough indication of the service demands placed on the system. The latter provided an indication of the capacity of the system, and to some extent it gave an indication of the ability of the system to meet new service demands.

In the NSA, the median average use of water was about 136,000 liters (35,928 gallons) per day for those 19,000 independent community systems for which information was available. The range of the systems' average daily use (as calculated during the year preceding the NSA study) was from 1,000 liters (264 gallons) through 214 million liters (57 million gallons), as shown in Table VII-95. As to the maximum daily design capacity, the median maximum daily amount which the system could supply was about 546,000 liters (144,000 gallons). The range (Table VII-95) was from 3,000 liters (793 gallons) to 2.7 billion liters (719 million gallons).

A related aspect of community systems—the number of connections metered to determine the volume of water used by customers—was difficult to put

Table VII-95

Average Daily Use and Maximum Daily Design Capacity of Independent Community Systems

		Nation	
Quantity in Liters	Approximate Quantity in Gallons	Number of Systems	Percent of Systems
Average Daily Use (during year preceding NSA)			
1,000 - 5,000	264 - 1,320	800	2.8
5,001 - 50,000	1,321 - 13,200	5,100	16.9
50,001 - 100,000	13,201 - 26,418	2,400	7.8
100,001 - 200,000	26,419 - 52,836	2,200	7.3
200,001 - 300,000	52,837 - 79,254	1,700	5.7
300,001 - 500,000	79,255 - 132,090	1,600	5.4
500,001 - 1,000,000	132,091 - 264,180	2,200	7.3
1,000,001 - 2,000,000	264,181 - 528,360	1,500	4.9
2,000,001 - 5,000,000	528,361 - 1,320,900	500	1.7
5,000,001 - 10,000,000	1,320,901 - 2,641,800	200	0.6
10,000,001 - 20,000,000	2,641,801 - 5,283,600	100	0.5
20,000,001 - 100,000,000	5,283,601 - 26,418,000	200	0.8
100,000,001 - 214,000,000	26,418,001 - 56,534,520	20	0.1
Could not be determined		11,500	38.3
Total		30,000	100.1
Maximum Daily Design Capacity			
3,000 - 250,000	793 - 66,045	5,600	18.7
250,001 - 500,000	66,046 - 132,090	2,400	8.1
500,001 - 1,000,000	132,091 - 264,180	3,500	11.7
1,000,001 - 2,000,000	264,181 - 528,360	2,100	6.9
2,000,001 - 3,000,000	528,361 - 792,540	800	2.6
3,000,001 - 5,000,000	792,541 - 1,320,900	1,700	5.8
5,000,001 - 10,000,000	1,320,901 - 2,641,800	1,000	3.0
10,000,001 - 100,000,000	2,641,801 - 26,418,000	600	2.0
100,000,001 - 2,725,000,000	26,418,001 - 719,000,000	200	0.6
Could not be determined		12,200	40.6
Total		30,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

into perspective without reference to other features of the systems, particularly their financial arrangements. The NSA results revealed a striking dichotomy in metering arrangements: in nearly half (48.0 percent) of all independent community systems, none of the connections were metered, while in a proportion nearly equivalent to the other half (46.7 percent), 95 percent or more of the connections were metered. In another 4.9 percent of systems, the proportion of metered connections rose evenly from 1 percent through 95.0 percent; in 0.4 percent of the systems, the information could not be obtained.

The proportion of independent community systems without metered connections was much smaller than the proportion of intermediate systems without metered connections (see report on intermediate systems earlier in this chapter), but the proportion still was quite large. Since metering is essential to most commonly used methods for billing customers, the lack of metering had significant economic implications. One possible implication was that many of the community systems were so small that customers were charged a flat rate for water, no matter how much they used. Another possible implication, supported by other research,[30] was that many small community systems did not make direct water-use charges, but instead made overall service charges (in a trailer park, for instance) or relied on funds from the general community budget.

Facilities for distributing and treating water

A profile of the major water distribution and treatment facilities in independent community systems was developed in two ways. First, the relevant facilities installed either during initial construction of the system, or during subsequent alteration, were assessed. Second, specific items of equipment being used to treat water at the time of the NSA survey were inventoried.

As to the first step in developing the profile, it was assumed that, at original construction, systems acquired basic equipment such as distribution lines, water sources, and pumps. In addition, certain other equipment was reported at the 9,000 systems which had had no subsequent major alterations at the time of the NSA, and which therefore reported only equipment installed at original construction. The NSA findings showed that, excluding systems among the 9,000 for which the information could not be obtained, 5,000 had original-construction storage tanks, 4,000 had water treatment facilities, 1,000 had pressure tanks, and 900 had other facilities. As to the 21,000 systems which reported major alterations (and which therefore did not report original-construction equipment), equipment added during the alterations ranged from service lines to pressure tanks. Specifically, 10,000 systems had added pumps, 8,000 had added new service lines, 6,000 had added wells or made well improvements, 7,000 had added storage tanks, 5,000 had added new treatment facilities, 1,000 had added reservoirs or dams, 500 had added pressure tanks, and 800 had added other facilities.

As to treatment processes in use at the time of the NSA survey, it was discovered that some treatment processes were employed at about 18,000 independent community systems (60.6 percent), but not at 12,000 systems (39.4 percent). Chlorination was by far the most frequently employed (Table VII-96). Other processes were used infrequently. However, there were several processes (fluoridation, aeration, coagulation, and flocculation) which although used infrequently in community systems, were not used at all in intermediate systems. As to the nature of these processes, fluoridation is the process of adding controlled quantities of fluorides to the water to reduce tooth decay. Aeration is the process of bringing water and air into contact with each other (by spraying water into the air or by other mechanical procedures, for example) in order to oxidize or remove objectionable substances, or to add oxygen to the water to improve taste. Coagulation and flocculation are distinct but related processes by which suspended matter is conditioned so that it will settle out of the water.

Table VII-96

Treatment Processes and Treatment Devices for Independent Community Systems

Characteristic*	Nation Number of Systems	 Percent of Systems**
Treatment Processes		
Chlorination	17,000	57.5
Filtration	4,000	14.1
Fluoridation	2,000	6.5
Softening	2,000	6.0
Aeration	600	2.1
Coagulation	500	1.6
Flocculation	300	1.0
Other treatment processes	2,000	6.2
Treatment Devices in Operation		
Chlorinator	14,000	47.7
Chemical feeder unit	3,000	10.8
Filter	3,000	9.3
Fluoridator	2,000	6.4
Softener	2,000	5.8
Settling tank	1,000	4.0
Aerator	400	1.2
Other treatment devices	700	2.4

*Data are for systems having at least one process or device, as indicated; some systems may have had more than one of each.

**Percentages are of the total number of independent community systems (30,000).

Generally, the proportion of systems reporting a given treatment process was similar to that reporting functioning devices necessary for that process (Table VII-96), but there were exceptions. The most prominent difference was that 10 percent more systems reported chlorination than actually had functioning chlorinators. (This same trend was apparent in intermediate systems, as already reported.) More independent community systems reported filtration than had filters, specified in Table VII-96, but the filtration process may have referred to the use of unspecified filters installed in conjunction with other equipment, but not classified as "miscellaneous" by system authorities.

Overall, the most striking finding was that nearly 40 percent of the independent community systems did not treat their water at all. Authorities at these 12,000 nontreating systems may have believed that water quality was adequate without treatment, or they may have decided against treating for any one of a number of financial, technical, or other reasons. The lack of treatment will be considered later in this chapter in relation to the reported results of water quality tests, and in a subsequent chapter in relation to water quality.

System operators

The increased size and complexity of community systems as opposed to intermediate systems may have been reflected in the number of operators used in one as opposed to the other type of system. As seen in Table VII-97, most independent community systems had at least one equipment operator, and nearly half had more than one operator. In contrast, about 35 percent of all intermediate systems had no operators, and only about 15 percent of all intermediate systems had more than one operator (Table VII-48).

The work status of the operators also was quite different in community as opposed to intermediate systems, as can be seen by comparing Tables VII-48 and VII-97. Whereas most intermediate systems with operators (84.6 percent) had at

Table VII-97

Number and Work Status of Operators of Independent Community Systems

Characteristic	Nation: Number of Systems	Nation: Percent of Systems
Number of Operators		
0	2,000	7.1
1	13,000	43.8
2	9,000	28.9
3	3,000	10.2
4	1,000	4.1
5 - 10	1,000	4.0
11 - 20	200	0.5
21 - 50	200	0.8
More than 50	2	0.0
Could not be determined	100	0.5
Total	30,000	99.9
Status of Operators*		
Volunteer	7,000	25.0
Paid part-time	14,000	50.0
Paid full-time	10,000	35.7

*A total of about 28,000 systems had at least one operator; in a system with several operators, however, each operator could be in a different status category, and the column total thus exceeds 28,000. The percent of systems here refers to the proportion of the 28,000 systems which had at least one operator in the respective categories.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

least one volunteer, most independent systems (85.7 percent) had at least one paid part-time or paid full-time operator, and only 25 percent had volunteer operators. Also, whereas the status generally was the same for all operators in intermediate systems, this was not always true for operators in community systems. Specifically, 2,950 independent community systems had operators in two of the work status categories; 50 independent community systems had operators in all three of the work status categories.

Operators at independent community systems also were more likely than those at intermediate systems to have had special training or schooling in the operation of equipment at the system. Whereas most intermediate systems had operators who had no special training, about 29 percent of all 30,000 independent community systems had one operator who had received such training; about 16 percent had two or more operators who had had such training. About 53 percent of all of the systems had no operators with such training, and about 2 percent of the systems could not provide information on the subject.

As to the degree of special training within systems, all of the operators at about 26 percent of all independent community systems had had special training. Half of the operators had had special training at about 9 percent of the systems. Operators at about 53 percent of the systems had had no special training, as already noted; the degree of special training could not be determined at about 10 percent of the systems.

Operation of community systems as opposed to intermediate systems thus required more employees, more diversity in employee job status, and more extensive employee training. The operation of community systems also required more labor time. Whereas each month the operation of about 83 percent of all intermediate systems required less than one man-day (equivalent to the work of one person during eight hours), the operation of about 69 percent of all independent community systems required one man-day or more each month. The median for independent systems (excluding those for which no information was available) was 1.6 man-days per month. In the case of a very few systems, the work required at least 8,000 total hours of work by the operators each month. This was about seventeen times the maximum amount of time required to operate an intermediate system. Although the maximum amount of time required was very large for a few community systems, most systems (85 percent, or about 25,000) needed a total of 400 man-hours of work each month (50 man-days per month) or less. About 24 percent of all independent community systems required less than one man-day of work monthly, and about 8.6 percent of the systems could not provide information on the subject.

System performance

A primary goal of the foregoing array of equipment and manpower was to provide reliable service to customers. Success in meeting this goal was assessed in the NSA by investigating system performance. Performance was quantified in terms of the number of system breakdowns during the preceding year, and also in terms of the number of difficulties such as equipment problems, weather problems, or other conditions which interfered with the acquisition of water from the source.

As to breakdowns, the independent community systems had more difficulties than did the intermediate systems. Whereas only about 26 percent of intermediate systems reported one or more breakdowns during the preceding year (Table VII-49), more than twice that proportion (55 percent) of independent community systems reported breakdowns (Table VII-98). Although a few systems had numerous breakdowns, most had five or fewer.

Breakdowns were incidents which interrupted the system's capacity to acquire, treat, or deliver water in its usual way. Since the system might have emergency equipment or a reserve supply to guard against interruption of service if breakdowns occurred, a separate NSA inquiry dealt with the possibility of

Table VII-98

Frequency and Reasons for Breakdowns in Independent Community Systems During Previous Year

Characteristic	Nation Number of Systems	 Percent of Systems
Number of Breakdowns During Previous Year		
0	13,000	43.9
1	8,000	26.6
2 - 5	5,000	15.3
6 - 10	2,000	8.1
11 - 20	1,000	3.4
21 - 50	200	0.7
51 - 75	70	0.2
More than 75	60	0.2
Could not be determined	400	1.4
Total	30,000	99.8
Reasons for Breakdowns		
Pump malfunction	8,000*	51.5*
Ruptured lines	8,000	50.2
Power failure	2,000	14.6
Adjustment for pH level of water	2,000	12.0
Treatment equipment malfunction	400	2.3
Flooding	70	0.4
Drought	50	0.3
Vandalism	10	0.0
Other reasons	1,000	6.9

*Numbers and percentages refer to the approximately 16,000 systems which had at least one breakdown. However, one system may have given several reasons for one breakdown, and thus may have been tallied separately for each of several reasons. As a result, the total number of systems in the table exceeds 16,000, and the total percent of systems exceeds 100.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

interrupted service after breakdowns. That is, systems reported first on the number of breakdowns, then on the number of breakdowns which resulted in loss of service to customers.

Specifically, of the approximately 16,000 independent community systems with one or more breakdowns during the preceding year, about 11,000 (approximately 70 percent) reported that at least one of the breakdowns caused interruption of service to customers (not tabulated in Table VII-98). Some of the systems—about 50—reported that there were more than 95 breakdowns resulting in loss of service. Although this total was only a small percentage (0.3 percent) of all systems reporting breakdowns, the situation could have been a serious inconvenience for customers, and many customers could have been affected if the systems were large ones. As to other systems, about 50 had from 50 to 73 breakdowns resulting in loss of service; about 90 (approximately 0.6 percent of all systems with breakdowns) had from 25 to 50 breakdowns resulting in loss of service; about 800 (approximately 5 percent of all systems with breakdowns) had from ten to 25 breakdowns causing loss of service; and about 10,000 (approximately 64 percent of all systems with breakdowns) had fewer than ten breakdowns resulting in loss of service.

As to the reasons for breakdowns, pump malfunctions and ruptured lines were the most common problems, as they were for intermediate systems (compare Tables VII-98 and VII-49). Power failure was the third most common cause of breakdown for both community and intermediate systems, but it was proportionately a more frequent cause for breakdowns among community systems. Adjustment for the pH level of the water was one reason for breakdown listed for community but not for intermediate systems. The pH level itself would not cause a breakdown except in extreme conditions, but the level could force operators to deactivate major segments of equipment, or to use alternative reserve supplies, until corrective measures were taken. For example, the federal proposed national secondary drinking water regulations establish a recommended (not federally enforceable) pH range of 6.5 through 8.5.[31] Levels below that range may cause corrosion; levels above it may cause mineral incrustations and bitter taste, and may decrease the germicidal activity of chlorine. Various treatment processes, such as the addition of certain chemicals, may be required to counteract unacceptable pH levels. This sort of adjustment apparently required interruption of the operation at 2,000 independent community systems.

In terms of difficulties which interfered with acquisition of water from the source, the NSA results showed that 3,700 independent community systems (about 9 percent of all independent systems) sometimes had such difficulties. Since about 90 percent of all independent community systems had groundwater sources (Table VII-94), it followed that more difficulties would be encountered in systems using groundwater, and this was indeed the case (Table VII-99). Yet this result is misleading unless it is put into perspective. That is, since a total of 27,000 independent community systems used groundwater, only 11.1 percent (3,000 out of 27,000) had difficulties obtaining water from the source. In contrast, since a total of only 3,000 systems used surface water, 23.3 percent (700 out of 3,000) had difficulties obtaining water from that source. In other words, by this measure, groundwater was about twice as reliable a source as was surface water.

The type of difficulties varied according to the source. Whereas equipment breakdowns were by far the most common difficulty for intermediate systems (Table VII-50), they were only the second most common problem for independent community systems using groundwater, and even less of a problem for systems using surface water (Table VII-99). Although the equipment at the community systems probably was more extensive than at intermediate systems, it also may have been of better quality, and it may have been better maintained. At any rate, for community systems, the foremost difficulty in obtaining water from groundwater sources was related to severe weather problems such as drought, windstorm,

Table VII-99

Difficulties in Obtaining Water for Independent Community Systems Using Groundwater and Surface Water

	Nation	
Difficulties	Number of Systems*	Percent of Systems*
Groundwater		
No difficulties	24,000	89.9
Weather problems	1,000	3.6
Equipment breakdowns	800	2.7
Insufficient quantity	500	2.0
Contamination	300	1.0
Loss of supply	100	0.5
Other difficulties	400	1.4
Surface Water		
No difficulties	2,300	66.9
Insufficient quantity	600	17.8
Weather problems	400	12.0
Contamination	100	3.7
Loss of supply	60	1.7
Equipment breakdowns	40	1.2
Other difficulties	10	3.5

*Number and percent of systems have as the base the total number of independent community systems using the respective sources: a total of 27,000 systems used groundwater; 3,000 used surface water (some systems used more than one source). However, one system might report more than one type of problem. Because of this potential for double counting, numerical and percentage totals are excluded.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

or flood. Although weather problems also were prominent among the difficulties in obtaining water from surface sources, the major difficulty was that the quantity of water was sometimes insufficient. This meant that the surface water source could not meet demand for some reason, such as water depletion because of customer overuse or because of below-average precipitation.

Another less common difficulty for community systems was complete, although not necessarily permanent, loss of the supply. This situation occurred when the quantity or quality of the source diminished to the point where another source had to be used. Another problem was that contamination occasionally interfered with use of the source.

Water test history at independent community systems

In addition to availability, water quality was another indication of the success of the overall system operation in providing satisfactory service to customers. In view of this, a number of inquiries were made in the NSA to determine the water testing practices at independent community systems, as also was done for intermediate systems. Information about both bacteriological and chemical testing was obtained. Since infectious diseases caused by bacteria have been the primary concern in water hygiene (see Chapter V), bacteriological testing generally is done more frequently and consistently than chemical testing, and inquiries about the programs for bacteriological testing thus were more detailed than those about the programs for chemical testing.

— Bacteriological water quality tests

Whereas bacteriological testing was done at about only 22 percent of intermediate systems (189,000 systems), that testing was done at about 91 percent of independent community systems (27,400 systems), as seen in Table VII-100. Larger public systems have historically received more attention in terms of water

Table VII-100

Independent Community Systems Performing Bacteriological Water Quality Tests, Frequency of Tests, and Organizations Conducting the Tests

	Nation	
Characteristic	Number of Systems	Percent of Systems
Testing Performed		
Bacteriological tests performed at some time	27,400	91.2
Bacteriological tests not performed at any time	2,000	8.1
Could not be determined	200	0.7
Total	30,000	100.0
Frequency of Tests for Systems Performing Tests at Some Time		
Not performed regularly	100	0.4
Once a year or less often	1,000	4.8
At least once every six months	2,000	5.9
At least once every three months	800	3.1
At least once every month	21,000	78.0
At least once every week	2,000	5.7
At least once every day	300	1.1
Could not be determined	300	1.0
Total	27,400	100.0

Table VII-100 continued

Characteristic	Nation Number of Systems	 Percent of Systems
Organizations Conducting Tests		
Public health department	16,000	58.4
State environmental department	8,000	29.2
Private laboratory	2,000	7.3
System laboratory	500	1.9
System laboratory and either public health department or state environmental department	100	0.5
Public health department and private laboratory	80	0.3
Hospital laboratory	50	0.2
Federal laboratory	10	0.0
Other	400	1.5
Could not be determined	200	0.7
Total	27,400	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

quality testing, and that tendency was strengthened by passage of the 1974 Safe Drinking Water Act, which mandated water quality regulations for community-size systems, but generally not for intermediate-size systems. The result in different emphasis according to system size was striking, since bacteriological testing occurred in nine out of ten community systems as opposed to only two out of ten intermediate systems.

Another striking contrast between bacteriological testing at intermediate and at community systems was that testing, when done, was done much more frequently at community than at intermediate systems (compare Tables VII-100 and VII-51). Most testing at intermediate systems was done irregularly or no more than once a year. In contrast, most testing at community systems was done once every month or more often. Again, historic concern and recent drinking water quality legislation probably were two factors which promoted a much more rigorous testing schedule for community-size systems than for intermediate-size ones.

As to organizations conducting the bacteriological tests, most community systems relied on facilities outside of their own organization, as was true for intermediate systems. Most tests for both types of systems were done by state or local public health departments, by state environmental departments, or by private laboratories. However, as can be seen in Tables VII-51 and VII-100, a larger proportion of community than intermediate systems used their own laboratories (1.9 percent compared to 0.2 percent). At the same time, a larger proportion of intermediate than community systems used federal laboratories for the tests (3.6 percent, compared to a fraction of 1 percent).

Results of the bacteriological tests were assessed in the NSA by inquiring about the number of tests which showed that the water quality met the local, state, or federal regulations which concerned system officials. Here, in order to focus on the current water quality record of the systems, the results are limited to those obtained within one year of the survey. Also, for convenience, the results are limited to a total of twelve tests. Thus, for systems testing each week, for example, the results are assessed for the preceding twelve weeks—even though the systems tested about 50 times during the year. Furthermore, the report here presents information only for 25,000 systems for which test results were available. At the remaining 5,000 systems, either information could not be obtained, or else testing was not done.

The NSA findings revealed that at 23,000 (92.4 percent) of the 25,000 systems, all bacteriological tests (a maximum of twelve, as noted above) showed results which met the prescribed levels. At nearly all the rest of the systems (6.4 percent), more than 90 percent of the tests showed results which met the prescribed levels. The findings are comparable to those reported previously for intermediate systems, indicating that when multiple-connection systems did perform bacteriological tests, the results generally were acceptable.

— Chemical water quality tests

Although independent community systems generally tested for bacteriological water quality, the systems were much less likely to test for chemical water quality. About 54 percent of the systems (16,000) reported that chemical tests (including physical tests) were performed, but about 46 percent (14,000) reported either that chemical tests were not performed, or that they did not know whether the tests were done. Overall, then, chemical water quality tests were reported at about 11,000 fewer systems than were bacteriological water quality tests.

As seen in Table VII-101, many of the systems which did chemical tests had done one during the preceding two years. The indication of increased testing since 1975 was consistent with promulgation of the EPA's National Interim Primary Drinking Water Regulations on December 24, 1975. Results of some of the chemical tests were obtained in the NSA, but because of variability in the year of the tests, in testing procedures, and in other conditions, NSA investigators

Table VII-101

Year of Most Recent Test for Chemical and Physical Water Quality in Independent Community Systems

Year of Most Recent Test	Nation	
	Number of Systems	Percent of Systems
1970 or earlier	480	3.0
1971 - 1974	1,200	7.5
1975	1,300	7.8
1976	1,200	7.8
1977	3,900	24.5
1978	7,100	44.1
Could not be determined	900	5.3
*Total	16,000	100.0

*Total of those systems performing tests.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

concluded that it was not warranted to assess the findings in terms of compliance with prescribed levels or in terms of possible implications for water quality.

Water test history at households served by independent systems

The preceding section presented results of water quality tests done on specimens taken from the water supplies of independent systems. Here, the focus shifts to water quality tests done on specimens taken from the major supplies at households served by the independent systems. The information is the equivalent of that reported on for households served by individual systems. In the latter households, however, the information was for both the household and for the individual system, since the two were synonymous. Here, the household information generally refers to a separate test done in addition to that performed by the system. In this regard, the household is considered part of the overall system of water delivery, and household test information thus provides an additional assessment of water quality associated with community systems.

There are three important qualifications in a side-by-side consideration of system and household water test results. First, the water quality at the household may differ from that in the system distribution network due to the presence of certain types of plumbing or treatment devices in the household. Second, the information about the system tests is more comprehensive than the information about the household tests, particularly in regard to the water chemistry tests. Third, the system test in some cases may be referred to examination of water at a household served by the system. This was possible since systems performed the tests on samples drawn from different points in the production and distribution network, and there was no way in the NSA to determine the exact point of withdrawal. Thus, although it was statistically unlikely, it was possible that separate test results reported to the NSA by the household and by the system actually referred to the same, single test performed by the system at the household.

These qualifications—and others—make it impossible to make a detailed comparison between the findings reported by the systems and those reported by the households. The findings are presented here to provide additional information regarding the water supplies provided by systems, but the most appropriate comparison is among the findings for different households. Thus, the primary focus here is on findings in households served by community systems as compared to findings in households served by intermediate and individual systems. (Test results for specific constituents was too fragmentary and unreliable among households served by intermediate systems to be reported in this study.)

—Household test results

A total of 8.5 million households (38.7 percent of all rural households) were served by independent community systems. Household water quality tests were performed at a very small proportion (only 5.5 percent) of these households. Tests were not performed at 89.7 percent of households, and it was not known whether tests had been performed at 4.7 percent. This was in sharp contrast to findings for households served by individual systems, where tests had been done at about 37 percent of households (see "Individual system water test history" earlier in this chapter).

Although testing was done in a much smaller proportion of households served by independent community systems than by individual systems, the frequency of testing was greater, as was the maximum number of tests performed. Specifically, more than two tests were performed in 19.4 percent of the former households, compared to 12.3 percent of the latter. In a single household served by an independent system, more than 95 tests were performed, whereas among individual-system households the maximum number of tests was 80.

The last test in households served by independent community systems was done from 1970 through 1979 in 70.6 percent of households, from 1960 through 1969 in 10.4 percent of households, and before 1930 in 1.2 percent of households. The test year was not known in 19.9 percent of households. This testing record was fairly similar to that for households served by individual systems.

The last test had been performed most often (in 58.1 percent of the households) to determine if a system alteration were needed. Installation of a new system was the reason for the test in 10.6 percent of the households. These two reasons for testing also were the leading reasons in households served by individual systems (in about 76 percent of those systems, combined). In about 16 percent of independent-community-system households, the testing was done for one of a variety of other reasons: the nature of the test ranged from a check on the water after a system breakdown to a test in association with the sale of the house. The reason for the test was unknown in 15.4 percent of households.

The tests were requested most often by local, state, or federal officials. This occurred in 33.5 percent of independent-system households, as opposed to only 19.9 percent of households served by individual systems. The requests came from household members in 26.3 percent of independent-community-system households, only about half the proportion of individual-system households in which the request was by a household member. The requests were from contractors, miscellaneous sources, or unknown sources in 27.3 percent of households served by independent systems.

One contrast in the additional reasons for testing at independent-system households versus individual-system households was consistent with the more formal organizational structure of independent systems. That is, the household test was reported to have been done as a standard independent-system procedure in 60,000 households (12.9 percent of independent-system households in which testing was done). The test, in other words, was initiated by the system as a standard response to the reason cited for the test. Theoretically, standard-procedure-testing could have been done in individual systems owned by an organization such as a private firm or cooperative, but few individual-system households reported that type of test.

As to the extensiveness of the household test, combined bacteriological and chemical testing was reported in 20.8 percent of independent-system households in which testing was done. Bacteriological tests alone were done in 12.5 percent of the households, and chemical tests alone were reported in 19.1 percent of the households. The type of testing was not known at nearly half (47.7 percent) of the households.

As to the results of the tests, a large proportion of the households did not know the outcome of the testing, a situation which was prevalent in individual-system households as well (see "Individual system water test history" earlier in this chapter). For example, the results of the bacteriological tests were not known at nearly 76 percent of households reporting that type of test. The results were reported to be acceptable (within the applicable standard) at about 24 percent of the households. In regard to the chemical tests for water quality, the test outcome was not known at about 87 percent of households. Of the seventeen constituents inquired about, only three—iron, calcium, and chromium—were found in amounts exceeding the applicable standard. Iron concentrations were excessive in only 2.6 percent of households (10,000), calcium in only 1.5 percent of households (6,000), and chromium in only 2.6 percent of households (10,000). Other constituents (a total of six) were found in unacceptable concentrations in individual-system households, but one constituent—chromium—was in unacceptable concentrations only in the independent-system households.

Regional variation in independent systems

The distribution of the 30,028 independent community systems in the four regions of the US generally paralleled the distribution of rural households in those regions. For example, the largest proportion of the systems—41.6 percent—were located in the South. The largest proportion of rural households—42.3 percent—also were located in the South. Similarly, 28.0 percent of the systems were located in the North Central, and 28.3 percent of the rural households also were located in that region. The parallel was not as close in the remaining two regions of the country, however. The Northeast, where 16.8 percent of the households were located, had only 11.4 percent of the independent community systems. In contrast, the West, where only 12.6 percent of the households were located, had 19.0 percent of the independent systems. This pattern was consistent with the relative prevalence of community supplies in the West.

Regional variation in size of independent systems

Although independent systems were proportionately more prevalent in the West, the size of independent systems as measured by number of connections tended to be smallest in the West. Specifically, the median number of connections was only 30.2 in the West, compared to 79.4 in the North Central, 65.5 in the Northeast, and 57.8 in the South. Thus, the independent systems in the North Central generally were by far the largest in the US. The median number of connections in the North Central systems was more than two and one-half times the median in the Western systems, and was decidedly larger than the median number in the Northeast or the South. As was true for the nation as a whole, the majority of independent systems in each region had 100 or fewer connections; about 90 percent of the systems in each region had 500 or fewer connections.

Though North Central systems were largest in terms of number of service connections, they were about the same size as elsewhere in terms of distribution-line length. The median length of the distribution lines was 2.9 kilometers (1.8 miles) in North Central systems, 2.5 kilometers (1.5 miles) in Southern systems, 1.8 kilometers (1.1 miles) in Northeastern systems, and 1.7 kilometers (1.06 miles) in Western systems. Excluding systems for which information was not available (in proportions ranging from about 8 percent in the South through about 16 percent in the West), about 90 percent of systems in all regions except the South had no more than 20 kilometers (12.4 miles) of distribution lines. In the South, about 80 percent of the systems were within this size range, but about 20 percent were larger and had up to 60 kilometers (37.3 miles) of lines.

Regional variation in source, ownership, and age of independent systems

Although surface water was used infrequently by independent systems (in only 11.5 percent of systems nationally), that use varied considerably by region. As seen in Table VII-102, surface water was used as a source in only 4.8 percent of North Central independent systems, but in 21.3 percent of Western systems. The proportion (17.1 percent) of Northeastern systems using surface water also was relatively large, although 4.2 percent of the Northeastern systems used both surface and groundwater. In comparison, a combination of surface and groundwater was used in 2 percent or less of independent systems elsewhere.

Independent systems in the West and Northeast also differed from other systems nationally in terms of ownership (Table VII-102). Specifically, only 20.9 percent of Western systems were owned by public bodies, compared to 36.8 percent of systems nationally; 42.9 percent of the Western systems were owned by individuals, compared to only 31.4 percent of systems nationally; and 4.4 percent of Western systems were owned by Indian tribes, compared to 0.0 percent elsewhere in the nation. In the Northeast, public ownership was similar to that in the nation as a whole, but ownership by private firm was much larger than for the nation as a whole. To summarize the ownership arrangements by region, ownership by a public

Table VII-102

Regional Variation in Source, Ownership, and Age of Independent Community Systems

	Number and Percent of Systems				
Characteristic	Nation	Northeast	North Central	South	West
Source*					
Groundwater	27,000	2,992	7,995	11,483	4,617
	90.2%	87.1%	95.2%	91.9%	81.0%
Surface water	3,000	588	404	1,236	1,212
	11.5%	17.1%	4.8%	9.9%	21.3%
Ownership					
Public	11,00[illegible]	1,150	4,271	4,448	1,190
	36.[illegible]%	33.5%	50.9%	35.6%	20.9%
Individual	9,000	289	1,860	4,819	2,446
	31.4%	8.4%	22.2%	38.5%	42.9%
Private firm	6,000	1,834	1,207	2,149	889
	20.2%	53.4%	14.4%	17.2%	15.6%
Cooperative	3,000	149	1,050	839	900
	9.8%	4.3%	12.5%	6.7%	15.8%
Indian tribe	200	0	0	0	248
	0.8%	0.0%	0.0%	0.0%	4.4%
Other	10	0	0	0	5
	0.0%	0.0%	0.0%	0.0%	0.1%
Could not be determined	300	13	7	242	23
	0.9%	0.4%	0.1%	1.9%	0.4%
Total	30,000	3,435	8,395	12,497	5,701
	100.0%	100.0%	100.1%	99.9%	100.1%

Table VII-102 continued

	Number and Percent of Systems				
Characteristic	Nation	Northeast	North Central	South	West
Age of system (number of years since construction or alteration)					
Less than 1	5,000 15.5%	239 7.0%	348 4.1%	2,623 21.0%	1,436 25.2%
1 - 5	12,000 38.6%	1,925 56.1%	2,246 26.8%	5,401 43.1%	2,010 35.3%
6 - 10	7,000 24.5%	282 8.1%	3,018 35.9%	3,432 27.5%	621 11.0%
11 - 15	2,000 6.6%	257 7.5%	1,250 14.9%	369 2.9%	120 2.1%
16 - 20	1,000 3.0%	136 4.0%	352 4.3%	216 1.7%	203 3.6%
21 - 50	2,000 5.3%	399 11.6%	627 7.3%	195 1.5%	361 6.3%
More than 50	200 0.9%	26 0.7%	244 2.8%	0 0.0%	0 0.0%
Continuous improvements	800 2.6%	1 0.0%	85 1.0%	229 1.8%	455 8.0%
Could not be determined	1,000 3.1%	170 4.9%	225 2.8%	32 0.4%	495 8.6%
Total	30,000 100.1%	3,435 99.9%	8,395 99.9%	12,497 99.9%	5,701 100.1%

*Some systems used both groundwater and surface water, so totals can exceed total number of systems, and percentages can exceed 100.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

body predominated in the North Central, ownership by an individual predominated in the West and in the South (although ownership by a public body also was common in the South), and ownership by a private firm predominated in the Northeast.

As to the age of independent systems—determined either by the number of years since original construction or by the number of years since subsequent major alteration—the systems in the South were distinct from those in other regions. Specifically, about 92 percent of all of the Southern systems were ten years of age or less, compared to no more than 72 percent in the other regions (Table VII-102). By contrast, only 6.1 percent of the Southern systems were more than 10 years old; for North Central systems, about 29 percent were in this condition. In terms of median age, North Central systems were oldest: median age was about seven years in North Central systems, three years in Northeastern systems, two years in Southern systems, and one year in Western systems. Continuous improvements (equivalent to an age of less than one year) were most frequent in Western systems.

Regional variation in water usage, maximum design capacity, and metered connections

In terms of both daily water usage (production) and daily design capacity, independent systems in the North Central had the largest operations, and systems in the Northeast had the smallest. Specifically, the median average daily use of water for systems for which the information was available was 184,042 liters (48,620 gallons) in North Central systems, 169,770 liters (44,850 gallons) in Western systems, 111,511 liters (29,459 gallons) in Southern systems, and 75,181 liters (19,861 gallons) in Northeastern systems. The median maximum daily design capacity was 763,131 liters (201,604 gallons) in North Central systems, 674,115 liters (178,088 gallons) in Western systems, 507,173 liters (133,985 gallons) in Southern systems, and 258,919 (68,401 gallons) in Northeastern systems.

The regional information about the number of connections which were metered paralleled the data for the nation as a whole in that most systems had one of two opposite strategies. That is, most systems in each region either did not meter at all, or, if they did meter, they metered all, not just a portion, of the connections. However, whereas the proportion not metering, and the proportion metering nearly all connections were about the same in the nation (about 48 percent did not meter, while about 47 percent metered 95 percent or more of their connections), the respective proportions varied among the regions. For example, in the West, 64.5 percent of independent systems did not meter, and 28.0 percent metered 95.0 percent or more of all connections. Comparable percentages of systems not metering versus those metering nearly all connections in the other regions were, respectively: 58.2 percent versus 35.1 percent in the North Central, 41.5 percent versus 49.0 percent in the Northeast, and 35.4 percent versus 62.8 percent in the South. Clearly, metering was by far the most extensive in Southern systems, the least extensive in Western systems. Fewer than 95 percent of connections were metered in a small proportion of systems in each region, and information was not available for a small proportion of systems in the North Central (1.3 percent) and in the South (0.1 percent).

To summarize the size-related information, the data about regional variations in water usage and in maximum capacity reinforced the impression that the North Central systems had the largest operations. That is, the North Central systems had the largest median values for average daily water use and maximum design capacity—as well as the largest median values for the number of connections and length of distribution lines (see section above on "regional variation in size of independent systems"). The Western systems, although smaller in terms of the median number of connections and length of distribution lines, were second largest in terms of median daily water use and maximum design capacity. This finding may have indicated that the Western systems generally were required to serve fewer customers, but that the customers (some of which may have been industrial or strictly agricultural ones rather than rural households) generally needed larger quantities of water. This possibility was consistent with the NSA discovery that median average daily per capita consumption of water in rural households which were metered and billed for water was largest in the West and South, and with the further finding that the mean average daily per capita consumption was largest in the West (see "subnational variation in recorded quantity," Chapter V). On the other hand, although the Western systems tended to produce more water than systems in any region except in the North Central, the Western systems tended to meter connections less often than did systems in other regions.

Regional variation in facilities for distributing and treating water

There was considerable regional variation in basic equipment which was either installed originally in the systems or else added in subsequent major alterations. As to originally installed equipment (other than basic equipment such as distribution lines, pumps, and installations associated with the water source), the proportion of Northeast systems with originally installed treatment plants (67.5 percent of 1,060 systems) was larger than the proportion of systems in other regions (27.7 percent of 3,551 North Central systems, 41.7 percent of 3,419 Southern systems, and 48.9 percent of 1,136 Western systems). The proportion of Northeast systems with originally installed pressure tanks (49.2 percent) also was larger than the proportion of systems in other regions (1.9 percent of North Central systems, 13.3 percent of Southern systems, and 0.0 percent of Western systems). In contrast, storage tanks were originally included in a much smaller proportion of Northeast systems (19.6 percent) than of systems in other regions (53.8 percent of North Central systems, 68.3 percent of Southern systems, and 61.2 percent of Western systems). The base numbers of systems used here refer to all regional systems which reported original installations but which had no subsequent major alterations. The type of original installation was unknown in a very small proportion (less than 1 percent) of systems in all regions except in the Northeast, where the information could not be determined at nearly 29 percent of systems.

As to systems which reported major alterations (and which therefore did not report original-construction equipment), some regional variations occurred in the prevalence of added treatment facilities, storage tanks, pumps, wells, and pressure tanks. Variations were minor in the prevalence of added service lines and reservoirs. As to the former equipment, added storage tanks and wells were more common in North Central systems (in 46.4 percent and 53.6 percent of 4,844 systems, respectively) than in Northeast systems (in 34.1 percent and 32.1 percent of 2,375 systems, respectively), Southern systems (in 32.2 percent and 23.7 percent of 9,067 systems, respectively), or Western systems (in 24.1 percent and 20.3 percent of 4,565 systems, respectively). Added treatment facilities were most prevalent in Southern systems (in 33.7 percent of those systems compared to 24.0 percent of Northeast systems, 14.5 percent of North Central systems, and 7.0 percent of Western systems). Pumps and pressure tanks had been added most often in Western systems (in 56.8 percent and 9.2 percent of systems, respectively, compared to roughly 45 percent and less than 1 percent, respectively, in systems in other regions). The base numbers here refer to all regional systems which reported major alterations. There were no systems at which the information could not be determined.

Particular attention was given to the extent of water treatment at systems in the NSA, and it was found that treatment practices varied from region to region. Some type of treatment was practiced in nearly 71 percent of Southern systems, but in only about 41 percent of Western systems. Treatment was done in about 61 percent of Northeast systems and in about 59 percent of North Central systems.

As to trends in treatment processes in different regions, chlorination was done more frequently in systems in the South than in other regions (Table VII-103). Other processes (filtration, fluoridation, softening, aeration, and miscellaneous processes) were most common in North Central systems. Overall, however, the main finding was that most treatment processes were used relatively infrequently in independent systems, regardless of the regional location. The one major exception was chlorination, which was used in two-thirds of Southern systems, but in smaller proportions of systems in other regions. Generally, the trends in treatment devices actually in use at the time of the NSA paralleled the trends in treatment processes (Table VII-103). As evident in the data for the nation as a whole, however, there seldom was enough functional equipment to match the scope of reported treatment. For example, although nearly 67 percent of Southern systems reported chlorination, only 59.0 percent had functioning chlorinators.

Regional variation in system operators

As seen in Table VII-104, the number and the employment status of operators varied from region to region. The situation in the Northeast systems was notable. Specifically, all of the Northeast systems had operators, whereas some systems in each of the other regions did not. Furthermore, 71.2 percent of Northeast systems had two or more operators, compared to 51.1 percent of Southern systems, 46.2 percent of Western systems, and 37.3 percent of North Central systems. At the same time, operators were far more often either part-time or full-time paid employees at Northeast systems than at systems in other regions.

The operators at Northeast systems also were most likely to have received special training or schooling in the operation of equipment at the system. Such training for at least one operator was reported at about 60 percent of all Northeast systems, about 55 percent of all Southern systems, approximately 37 percent of all

Table VII-103

Regional Variation in Treatment Processes and Treatment Devices for Independent Community Systems

	Number and Percent of Systems**				
Characteristic*	Nation	Northeast	North Central	South	West
Treatment Processes					
Chlorination	17,000 57.5%	2,048 59.6%	4,595 54.7%	8,326 66.6%	2,310 40.5%
Filtration	4,000 14.1%	85 2.5%	1,820 21.7%	1,540 12.3%	779 13.7%
Fluoridation	2,000 6.5%	90 2.6%	1,201 14.3%	472 3.8%	200 3.5%
Softening	2,000 6.0%	97 2.8%	878 10.5%	812 6.5%	0 0.0%
Aeration	600 2.1%	29 0.8%	442 5.3%	161 1.3%	0 0.0%
Coagulation	500 1.6%	22 0.6%	42 0.5%	379 3.0%	25 0.4%
Flocculation	300 1.0%	13 0.4%	65 0.8%	178 1.4%	31 0.5%
Other treatment processes	2,000 6.2%	169 4.9%	1,427 17.0%	185 1.5%	94 1.6%

Table VII-103 continued

Characteristic*	Number and Percent of Systems**				
	Nation	Northeast	North Central	South	West
Treatment Devices in Operation					
Chlorinator	14,000 47.7%	1,935 56.3%	2,898 34.5%	7,379 59.0%	2,123 37.2%
Chemical feeder unit	3,000 10.8%	229 6.7%	1,318 15.7%	1,392 11.1%	317 5.6%
Filter	3,000 9.3%	62 1.8%	1,077 12.8%	980 7.9%	671 11.8%
Fluoridator	2,000 6.4%	114 3.3%	1,095 13.0%	498 4.0%	200 3.5%
Softener	2,000 5.8%	36 1.0%	899 10.7%	789 6.3%	26 0.5%
Settling tank	1,000 4.0%	65 1.9%	121 1.4%	746 6.0%	277 4.9%
Aerator	400 1.2%	0 0.0%	305 3.6%	66 0.5%	0 0.0%
Other treatment devices	700 2.4%	74 2.2%	490 5.8%	143 1.1%	26 0.5%

*Data are for systems having at least one process or device, as indicated; some systems may have had more than one of each.

**Percentages are of the total number of independent community systems: Nation, 30,000; Northeast, 3,435; North Central, 8,395; South, 12,497; West, 5,701.

Table VII-104

Regional Variation in Number and Work Status of Operators at Independent Community Systems

Characteristic	Number and Percent of Systems				
	Nation	Northeast	North Central	South	West
Number of Operators					
0	2,000 7.1%	0 0.0%	893 10.6%	377 3.0%	853 15.0%
1	13,000 43.8%	972 28.3%	4,333 51.6%	5,696 45.6%	2,160 37.9%
2	9,000 28.9%	1,718 50.0%	2,025 24.1%	3,628 29.0%	1,311 23.0%
3	3,000 10.2%	423 12.3%	565 6.7%	1,560 12.5%	528 9.3%
4	1,000 4.1%	256 7.5%	63 0.8%	446 3.6%	479 8.4%
5 - 10	1,000 4.0%	33 0.9%	477 5.6%	612 4.9%	77 1.4%
11 - 20	200 0.5%	11 0.3%	13 0.1%	111 1.0%	28 0.5%
21 - 50	200 0.8%	6 0.2%	2 0.0%	23 0.1%	206 3.6%
More than 50	2 0.0%	0 0.0%	0 0.0%	2 0.0%	0 0.0%
Could not be determined	100 0.5%	16 0.5%	24 0.4%	42 0.3%	59 1.0%
Total	30,000	3,435	8,395	12,497	5,701
	99.9%	100.0%	99.9%	100.0%	100.0%

Table VII-104 continued

Characteristic	Number and Percent of Systems Nation	 Northeast	 North Central	 South	 West
Status of Operators*					
Volunteer	7,000 25.0%	136 4.0%	2,300 30.8%	3,000 24.8%	1,566 32.7%
Paid part-time	14,000 50.0%	2,671 78.1%	3,133 41.9%	5,108 42.3%	2,586 54.0%
Paid full-time	10,000 35.7%	827 24.2%	3,065 41.0%	5,220 43.2%	1,201 25.1%

*The percent of systems here refers to the proportion of those systems which had at least one operator in the respective categories; the bases are the numbers of systems which had at least one operator: in the nation, about 28,000; in the Northeast, 3,419; in the North Central, 7,478; in the South, 12,078; and in the West, 4,789. In a system with several operators, each operator could be in a different status category, and the column totals thus exceed the total numbers of systems which had at least one operator.

North Central systems, and about 27 percent of all Western systems. Two or more operators had received the training at 22.3 percent of Northeast systems, 21.4 percent of Southern systems, 10.3 percent of Western systems, and 8.1 percent of North Central systems. The information was not available for 8.5 percent of systems (in the West) through 0.3 percent of systems (in the North Central).

The degree of special training also was greatest at Northeast systems. That is, all of the operators had received special training at 33.8 percent of Northeast systems, 33.4 percent of Southern systems, 19.0 percent of North Central systems, and 13.8 percent of Western systems. Exactly half of the operators had received special training at 17.2 percent of Northeast systems, 10.4 percent of Southern systems, 8.6 percent of North Central systems, and 1.5 percent of Western systems. The information was not available at a sizable proportion of Western systems (23.6 percent), nor at some North Central systems (11.5 percent), some Southern systems (4.6 percent), and a few Northeast systems (0.5 percent).

Although Northeast systems generally had more, specially trained operators, those systems did not require the most man-days per month to operate. The median number of monthly man-days for the operation of the Southern systems (excluding systems for which information was not available) was 3.5 days, compared to 1.9 days for both Northeast and North Central systems, and 1.3 days for Western systems.

Overall, the NSA data about system operators presented something of a paradox. That is, the Northeast systems tended to be among the smallest in terms of number of connections, length of distribution lines, average daily water production, and daily design capacity. Yet those systems tended to have the most operators, as well as the most operators with special training. In contrast, the North Central systems, although the largest, tended to have fewer operators and fewer operators with special training than systems in any region except the South.

In other words, there seemed to be an inverse relationship in the regions between system size and operator staffing.

Regional variation in system performance

System performance as measured by the number of breakdowns during the preceding year was generally similar in different regions. One exception was that although breakdowns had not occurred in a majority of systems in the Northeast and North Central, and in nearly 50 percent of systems in the West, the situation was different in Southern systems. Only 28.4 percent of the Southern systems had been free of breakdowns; nearly 66 percent of Southern systems had one through ten breakdowns, compared to about 44 percent of Western systems, 37 percent of North Central systems, and 37 percent of Northeast systems.

Although Northeast systems generally had no more breakdowns than systems in other regions, the breakdowns in Northeast systems were more likely to result in interruptions of service. That is, in about 86 percent of the 1,479 Northeast systems which had breakdowns, at least one breakdown caused interruption of service. In contrast, this situation occurred in about 77 percent of the 3,015 Western systems which had breakdowns, in about 67 percent of the 8,770 Southern systems which had breakdowns, and in about 63 percent of 3,145 North Central systems which had breakdowns. Information could not be obtained for a small proportion of all systems (4 percent or less) in the Northeast, North Central, and South.

As to reasons for the breakdowns, the proportions of systems reporting various specific, sometimes multiple reasons in each region were similar to the proportions for the nation as a whole (Table VII-98), with some exceptions. One major exception was that less than 7 percent of systems with breakdowns in each region except the South reported power failure as a reason (or as one of several reasons) for at least one of the breakdowns. In the South, however, about 22 percent of systems (1,932) reported breakdowns at least in part due to power failures. Another prominent exception was that less than 6 percent of systems with breakdowns in each region except the North Central reported adjustment for the pH level of the water as a reason for at least one breakdown. In the North Central, however, 42.3 percent of systems (1,329) had breakdowns which were at least in part due to pH adjustment.

In regard to difficulties which interfered with acquisition of water from the source, such difficulties were most prominent in the Northeast and West when systems were grouped without regard to type of source (either groundwater or surface water). That is, 24.0 percent of Northeast systems (823) and 20.0 percent of Western systems (1,140) sometimes had difficulties obtaining source water. Contrasting percentages were 9.3 percent of Southern systems (1,167) and 6.9 percent of North Central systems (582).

When the type of source was considered, difficulties were proportionately associated more often with surface water than with groundwater in each region. The difference was most prominent in the West, where 54.8 percent of systems (664) which used groundwater experienced source difficulties, compared to 11.8 percent of systems (544) which experienced difficulties with groundwater. Comparable surface water versus groundwater percentages and numbers of systems in the other regions were: 30.0 percent (174) versus 22.4 percent (666) in the Northeast; 7.2 percent (29) versus 6.9 percent (553) in the North Central; and 15.0 percent (186) versus 8.5 percent (981) in the South. In other words, even though the total number of systems which had groundwater source difficulties was greater in all regions except the West, the proportion of systems having surface water difficulties was substantially greater in all regions except the North Central. Groundwater thus appeared to be by far the most reliable source in all regions except, perhaps, the North Central.

The specific types of difficulties with groundwater generally were proportionately similar in each region. The proportions generally were similar to those for the nation as a whole (see Table VII-99). The one exception was the occurrence of "other difficulties" in about 11 percent of Northeast systems (330) using groundwater, compared to less than one percent of systems in each of the other regions. This situation was the major reason for the larger proportion of groundwater difficulties in the Northeast.

The system experience with surface water—in contrast to the experience with groundwater—varied sharply from region to region (Table VII-105). Difficulties with surface water were by far the most prominent in the West, where the largest proportion of surface water systems were located (see Table VII-102). Difficulties also were faily common in Northeast systems, but they were relatively uncommon in North Central and Southern systems. The most notable finding was that fully 45 percent of the 1,212 Western systems which used surface water had difficulties because of insufficient quantity of the sources. In the Northeast, on the other hand, the greatest single problem was unfavorable weather such as that which produced drought or flooding.

Regional variation in water test history at independent community systems — Bacteriological water quality tests

As is evident in Table VII-106, bacteriological testing was done at a much smaller proportion of independent systems in the West than in other regions. The contrast between Western and Northeastern systems was particularly sharp. About 26 percent of the former systems reported that tests were not performed at all, whereas all of the latter systems reported that tests were performed sometime. Once-a-month testing was most common at all systems (Table VII-106), but testing monthly tended to be somewhat less frequent at North Central systems than at systems in other regions.

Table VII-105

Regional Variation in Difficulties in Obtaining Water for Independent Community Systems Using Surface Water

	Number and Percent of Systems*				
Difficulties	Nation	Northeast	North Central	South	West
Surface Water					
No difficulties	2,300 66.9%	413 71.1%	375 92.8%	1,050 85.0%	548 45.2%
Insufficient quantity	600 17.8%	35 6.0%	0 0.0%	29 2.3%	549 45.3%
Weather problems	400 12.0%	110 18.7%	13 3.2%	150 12.1%	141 11.6%
Contamination	100 3.7%	0 0.0%	0 0.0%	91 7.4%	35 2.9%
Loss of supply	60 1.7%	25 4.2%	0 0.0%	21 1.7%	12 1.0%
Equipment breakdowns	40 1.2%	0 0.0%	16 4.0%	25 2.0%	0 0.0%
Other difficulties	10 3.5%	0 0.0%	0 0.0%	0 0.0%	12 1.0%

*Number and percent of systems have as the base the total number of independent community systems using surface water under the respective headings (some systems used more than one source): nation, about 3,000; Northeast, 588; North Central, 404; South, 1,236; and West, 1,212. However, one system might report more than one type of problem. Because of this potential for double counting, numerical and percentage totals are excluded.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-106

Regional Variation in Independent Community Systems Performing Bacteriological Water Quality Tests, and Frequency of Tests

Characteristic	Nation	Northeast	North Central	South	West
	Number and Percent of Systems				
Testing Performed					
Bacteriological tests performed at some time	27,400 91.2%	3,435 100.0%	7,822 93.2%	11,907 95.3%	4,211 73.9%
Bacteriological tests not performed at any time	2,000 8.1%	0 0.0%	355 4.2%	590 4.7%	1,490 26.1%
Could not be determined	200 0.7%	0 0.0%	218 2.6%	0 0.0%	0 0.0%
Total	30,000 100.0%	3,435 100.0%	8,395 100.0%	12,497 100.0%	5,701 100.0%

Table VII-106 continued

	Number and Percent of Systems				
Characteristic	Nation	Northeast	North Central	South	West
Frequency of Tests for Systems Performing Tests at Some Time					
Not performed regularly	100 0.4%	0 0.0%	103 1.3%	0 0.0%	0 0.0%
Once a year or less often	1,000 4.8%	0 0.0%	445 5.7%	709 6.0%	160 3.8%
At least once every six months	2,000 5.9%	186 5.4%	1,219 15.6%	0 0.0%	212 5.0%
At least once every three months	800 3.1%	302 8.8%	32 0.4%	356 3.0%	153 3.6%
At least once every month	21,000 78.0%	2,447 71.2%	5,497 70.3%	10,026 84.2%	3,393 80.6%
At least once every week	2,000 5.7%	481 14.0%	354 4.5%	559 4.7%	153 3.6%
At least once every day	300 1.1%	19 0.6%	16 0.2%	137 1.2%	140 3.3%
Could not be determined	300 1.0%	0 0.0%	156 2.0%	120 1.0%	0 0.0%
Total	27,400 100.0%	3,435 100.0%	7,822 100.0%	11,907 100.1%	4,211 99.9%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

The bacteriological tests were usually performed by public health departments or state environmental departments in all regions except in the Northeast. Specifically, tests were performed by one or the other of those agencies in 97.0 percent of systems performing tests in the North Central, in 93.8 percent of systems in the West, in 91.4 percent of systems in the South, but in only 52.9 percent of systems in the Northeast. In the Northeast, nearly 46 percent of tests were performed by private laboratories, compared to about 5 percent in the West, 1 percent in the North Central, and 1 percent in the South.

As to results of the bacteriological tests (the number of tests which were assessed varied as explained earlier in the national findings), all tests were reported to meet prescribed levels at over 90 percent of systems which tested in each region except the West. In the West, all tests met prescribed levels at 83.2 percent of systems, although at another 15.5 percent of Western systems, prescribed levels were met by about nine out of ten tests.

— Chemical water quality tests

Chemical tests for water quality were performed in about one-half of all independent systems in each region except in the Northeast. In the Northeast, the tests were performed in nearly 78 percent of all systems—decidedly more than in any other region. As to the currency of testing, nearly all of the most recent tests had been done during 1970-78; the proportion of tests increased sharply in the last two years of that time period. Results of the tests were not assessed in the NSA for reasons discussed earlier in the national section on chemical water quality tests.

Regional variation in test history at households served by independent systems

As reported earlier (in the "household test results" for the nation), water quality tests had been performed at only 5.5 percent of the 8.5 million households served by independent community systems. This level of testing did not vary greatly from region to region, although testing was slightly more common in North Central households. Specifically, professional testing was reported at 8.4 percent of 2.0 million North Central households, 5.4 percent of 1.2 million Northeastern households, 4.6 percent of 1.1 million Western households, and 4.4 percent of 4.2 million Southern households.

The frequency of tests in households which did testing generally was similar in all regions except the West. That is, testing had been done no more than twice at about 60 percent of the Northeastern, North Central, and Southern households served by independent systems. Testing rarely had been done more than twenty times in households in those three regions. In contrast, testing had been done from 30 to 75 times in 63.4 percent of Western households.

As to the year of the most recent test, about seven of ten households had had testing during 1970-78 in each region except the West. Testing was slightly more current in the West, where about eight of ten households had had the most recent test during 1970-78.

The single most common reason for the most recent test, in each region, was to determine if a system alteration were needed. This was the reason for testing in about 81 percent of households in the West, and in from about 32 percent to 67 percent of households in the three other regions. The second most common reason for the test in the Northeast was to check the water after a breakdown in the system; this reason was cited in about 30 percent of Northeastern households, but in no households in the other regions.

The most recent test was requested most often by local, state, or federal officials in all regions except in the Northeast, where the test was requested by an individual in 48.7 percent of households which tested and which were served by independent systems. The test was done as a standard procedure for the system serving the households in about 15 percent of households in the Northeast as well as in the South, but in only about 4 percent of systems in the North Central. Standard-procedure testing was by far the most common, however, in the West, where that reason was cited in about 33 percent of households in which tests had been done.

It was more likely in the Northeast and North Central that the last test was chemical rather than bacteriological in households in which only one type of test was performed. In the South, 24.0 percent of testing households had a bacteriological test only, whereas 12.2 percent had a chemical test only and 9.7 had a combination of both. In the West, 26.8 percent of testing households had a bacteriological test only, and none had a chemical test only. The percentage of households having a combination of tests was the same in the Northeast as in the South, but was 21.3 percent in the North Central and even higher in the West—fully 73.2 percent. The type of testing was unknown at large proportions (ranging from about 44 percent to about 77 percent) of households in all regions except the West, where the type of testing was known at all households.

The pattern of NSA findings about test results was dominated by the discovery that the results were not known in most households. In the Northeast, in fact, the bacteriological findings were known at none of the households in which bacteriological testing had been done. The results of chemical testing were unknown at about 90 percent of Northeastern households, but the results met the applicable standards in all households where the results were known.

In North Central households, the results of bacteriological tests were unknown at 82.1 percent of households (78,000), and the results were acceptable (within the applicable standards) at the rest (17,000). The results of chemical testing were unknown at roughly nine out of ten households, and the results were acceptable at the rest of the households for all constituents except iron and chromium. Concentrations of iron and chromium exceeded the applicable standards at 6.6 percent of households each (10,000).

In Southern households, the results of bacteriological testing were unknown at 73.3 percent of households (114,000), and the results were acceptable at the rest (42,000). The results of chemical testing were unknown at about nine out of ten households, and the results were acceptable at the rest of the households for all constituents except calcium. Concentrations of calcium exceeded the applicable standards at 4.3 percent of households (6,000).

In Western households, the results of bacteriological testing were known in a larger proportion of households (54.8 percent, or 28,000) than in the other regions. The results were acceptable in all of those households. The results of chemical testing also were known at a larger proportion of households (about four out of ten), and the known results were acceptable for all constituents.

SMSA/nonSMSA variation in independent systems

Of the 30,028 independent systems, 5,843 served households within SMSAs, 24,185 systems served households outside of SMSAs. For convenience, the systems will be referred to here as SMSA versus nonSMSA systems, but this terminology can be misleading. For example, a metropolitan system within an SMSA may have served a rural household in open country, and thus it would be called a nonSMSA system here. The designation thus refers only to the location of the rural household served, not to the location of the system itself, even though in many cases the households and the systems were, in fact, in the same general area.

SMSA/nonSMSA variation in size of independent systems

Although the SMSA and nonSMSA independent systems differed in some characteristics, as will be seen later, the systems were similar in size as measured by number of connections and length of distribution lines. Specifically, the median number of connections was 56.6 for SMSA systems, compared to 58.9 for nonSMSA systems. The median length of distribution lines was 2.0 kilometers (1.2 miles) in SMSA systems and 2.5 kilometers (1.6 miles) in nonSMSA systems.

SMSA/nonSMSA variation in source, ownership, and age of independent systems

Although groundwater was the predominant source for independent systems, whether serving SMSA or nonSMSA households, groundwater was slightly more prevalent in SMSA systems (in 94.2 percent) than in nonSMSA systems (in 89.2 percent). In contrast, about twice as large a proportion of nonSMSA systems (12.7 percent) as SMSA systems (6.4 percent) had surface water sources. About the same proportion of nonSMSA systems and SMSA systems, however, used both groundwater and surface water (2.0 percent and 0.6 percent, respectively).

As to ownership, similar proportions (about 30 percent each) of SMSA and nonSMSA systems were owned by individuals, and similar proportions (about 10 percent each) of SMSA and nonSMSA systems were owned by cooperatives. On the other hand, a much larger proportion of nonSMSA systems (40.1 percent) than SMSA systems (25.1 percent) were owned by a public body. Conversely, a much larger proportion of SMSA systems (35.3 percent) than nonSMSA systems (16.8 percent) were owned by a private firm.

In terms of the age of independent systems, determined either by the number of years since original construction or by the number of years since subsequent major alteration, SMSA systems tended to be older than nonSMSA systems. Specifically, the median age of SMSA systems was seven years, compared to 2.7 years for nonSMSA systems. Despite the difference in median ages, about nine of ten systems were less than twenty years old, regardless of whether the systems served SMSA or nonSMSA households.

SMSA/nonSMSA variation in water usage, maximum design capacity, and metered connections

In terms of both daily water usage (production) and daily design capacity, SMSA systems had the larger operation. Specifically, the median average daily use of water for systems for which the information was available was 260,784 liters (68,894 gallons) at SMSA systems as opposed to 113,916 liters (30,094 gallons) at nonSMSA systems. Similarly, the median maximum daily design capacity was 758,836 liters (200,469 gallons) at SMSA systems as opposed to 539,828 liters (142,612 gallons) at nonSMSA systems. On the other hand, metering was more extensive at nonSMSA systems, where metering was done at about 56 percent of all nonSMSA systems, than at SMSA systems, where metering was done at about 36 percent of systems. In addition, at least 95 percent of connections were metered at about 51 percent of all nonSMSA systems compared to about 31 percent of all SMSA systems.

SMSA/nonSMSA variation in facilities for distributing and treating water

There was some SMSA/nonSMSA variation in basic equipment which was either installed originally in the system or else added in subsequent major alterations. As to originally installed equipment (other than fundamental equipment such as distribution lines, pumps, and installations associated with the water source), the proportion of SMSA systems with originally installed treatment plants (54.6 percent of 1,556 systems) was larger than the corresponding proportion of nonSMSA systems (37.2 percent of 7,610 systems). However, the proportion of nonSMSA systems with originally installed storage tanks (57.5 percent) was larger than the corresponding proportion of SMSA systems (49.7 percent). Similarly, the proportion of nonSMSA systems with pressure tanks (13.6 percent) was larger than the corresponding proportion of SMSA systems (0.6 percent). The base numbers used here refer to all systems which reported original installations but which had no subsequent major alteration. The type of original installation could be determined in all but 0.4 percent of nonSMSA systems, but the type could not be determined in 19.4 percent of SMSA systems.

As to systems which reported major alterations (and which therefore did not report original-construction equipment), some SMSA/nonSMSA variations occurred in the prevalence of added treatment facilities, storage tanks, pumps, wells, and pressure tanks. Variations were minor in the prevalence of added service lines and reservoirs. As to the former equipment, added treatment facilities were most common at nonSMSA systems (at 26.4 percent of 16,564 systems) than at SMSA systems (at 6.5 percent of 4,287 systems), but the other equipment had been added more often at SMSA systems. The percentages of SMSA systems versus nonSMSA systems with the other added equipment were, respectively: 42.4 percent versus 31.8 percent, storage tanks; 56.6 percent versus 45.1 percent, pumps; 50.0 percent versus 25.9 percent, wells; and 10.6 percent versus 0.2 percent, pressure tanks.

Despite the differences in prevalence of installed or added treatment equipment, treatment practices were similar at SMSA and nonSMSA systems. Some type of treatment was practiced at about 60 percent of both SMSA and nonSMSA systems. There was only minor variation (less than 5 percent) in the prevalence of most specific treatment processes in use at the time of the NSA. This was true for filtration, fluoridation, softening, aeration, coagulation, and flocculation. Chlorination, however, was practiced at 59.6 percent of all nonSMSA systems compared to 49.1 percent of all SMSA systems.

Similarly, there was only minor variation in the prevalence of most treatment devices at SMSA and nonSMSA systems. This was true for all of the devices listed previously in Table VII-96, except for chlorinators and chemical feeder units. Chlorinators were in operation at 49.4 percent of all nonSMSA systems compared to 40.8 percent of all SMSA systems. On the other hand, chemical feeder units were in use at 16.1 percent of all SMSA systems compared to 9.6 percent of nonSMSA systems.

SMSA/nonSMSA variation in system operators

The overall number of operators was similar at SMSA and nonSMSA systems. The median number of operators was less than one for both SMSA and nonSMSA systems, and 90 percent of both SMSA and nonSMSA systems had three or fewer operators.

As seen in Table VII-107, however, the working status of operators varied some in SMSA versus nonSMSA systems. A larger proportion of nonSMSA systems had at least one volunteer, whereas a larger proportion of SMSA systems had at least one paid full-time operator. A similar proportion of SMSA and nonSMSA systems had at least one paid part-time operator.

A somewhat larger proportion of all nonSMSA systems (48.8 percent) than of all SMSA systems (41.8 percent) had at least one operator with special training. On the other hand, no nonSMSA system had more than 15 operators with such training. In contrast, 2.5 percent of all SMSA systems (148) had more than 15 operators with special training; furthermore, 2.4 percent of all SMSA systems (138) had 25 operators with such training. Nevertheless, although some SMSA systems had comparatively large numbers of specially trained operators, the degree of training tended to be somewhat greater at nonSMSA systems. That is, all operators at 26.9 percent of nonSMSA systems, compared to 20.7 percent of SMSA systems, had special training.

Although the overall number of operators was similar at both SMSA and nonSMSA systems, the operation of the nonSMSA systems tended to require more man-days per month. A median of about three man-days per month was required at nonSMSA systems (excluding systems for which information was not available), compared to a median of about one man-day per month at SMSA systems.

Table VII-107

SMSA/NonSMSA Variation in Work Status of Operators at Independent Community Systems

Characteristic	Number and Percent of Systems		
	Nation	SMSA	NonSMSA
Status of Operators*			
Volunteer	7,000 25.0%	988 17.5%	6,014 27.2%
Paid part-time	14,000 50.0%	2,863 50.6%	10,635 48.1%
Paid full-time	10,000 35.7%	2,568 45.4%	7,745 35.0%

*The percent of systems refers to the proportions of those systems which had at least one operator in the respective categories; the bases are the numbers of systems which had at least one operator: for the nation, about 28,000; for SMSA systems, 5,655; for nonSMSA systems, 22,109. In a system with several operators, each operator could be in a different status category, and the column totals thus exceed the total numbers of systems which had at least one operator.

SMSA/nonSMSA variation in system performance

System performance as measured by the number of breakdowns during the preceding year was somewhat superior at SMSA systems as opposed to nonSMSA systems. Specifically, 52.2 percent of SMSA systems, compared to 41.9 percent of nonSMSA systems reported no breakdowns. Just as the breakdown record was better at SMSA systems, the associated maintenance-of-service record also was better. That is, of the 2,789 SMSA systems which had breakdowns, about 50 percent reported that no breakdown resulted in loss of service. In contrast, of the 13,620 nonSMSA systems which had breakdowns, only about 26 percent reported that no breakdown produced loss of service. Information was not available for a small proportion of all systems (0.5 percent of SMSA systems and 2.0 percent of nonSMSA systems).

As to reasons for the breakdowns, the proportions of systems reporting specific reasons listed previously for the nation in Table VII-98 were similar for SMSA and nonSMSA systems, with a few exceptions. One exception was that breakdowns at least in part due to pump failures were more common among SMSA systems which had breakdowns (in 68.1 percent of those systems) than among nonSMSA systems (in 48.2 percent of those systems). Another exception was that breakdowns at least in part due to ruptured lines were more common among nonSMSA systems which had breakdowns (in 52.8 percent of those systems) than among SMSA systems (in 37.7 percent of those systems). Finally, other miscellaneous reasons for breakdowns were reported much more frequently by SMSA systems (by 18.5 percent of those systems) than by nonSMSA systems (by 4.6 percent of those systems).

As to difficulty in acquiring water from the source, this problem was slightly more prominent among SMSA than nonSMSA systems when systems were grouped without regard to type of source (either groundwater or surface water).

Specifically, 15.6 percent of SMSA systems (911) versus 11.6 percent of nonSMSA systems (2,801) sometimes had difficulty obtaining source water.

When the type of source was considered for SMSA systems, there was reversal of the usual relationship seen previously for the nation and the regions—that is, 16.3 percent of SMSA systems (896) which used groundwater reported some difficulties with that source. In contrast, only 8.6 percent of SMSA systems (1,848) which used surface water reported some difficulties with that source. The previously noted relationship was very strong for nonSMSA systems, however: 33.9 percent of nonSMSA systems (1,038) which used surface water had some difficulty with that source, but only 8.6 percent of nonSMSA systems (1,848) which used groundwater had some difficulty with that source.

The specific types of difficulties with groundwater were proportionately similar in SMSA and nonSMSA systems (the proportions were within five percentage points of each other for each specific difficulty listed in Table VII-99). Also, the specific difficulties each were within four percentage points of the proportions for the nation listed in Table VII-99. The system experience with surface water, on the other hand, varied sharply in SMSA and nonSMSA systems. As seen in Table VII-108, a greater proportion of nonSMSA than SMSA systems had difficulties of each type (the proportions for nonSMSA systems, however, were fairly similar to those for the nation as reported in Table VII-99). NonSMSA systems had particular problems with surface water limitations due to insufficient quantity or weather problems.

SMSA/nonSMSA variation in water test history at independent community systems — Bacteriological water quality tests

Bacteriological testing was done at about nine of ten independent systems, regardless of whether the systems were within, or outside of SMSAs. Once-a-

Table VII-108

SMSA/NonSMSA Variation in Difficulties in Obtaining Water for Independent Community Systems Using Surface Water

Difficulties	Number and Percent of Systems*	
	SMSA	NonSMSA
No difficulties	360 96.0%	2,027 66.1%
Insufficient quantity	8 2.1%	605 19.7%
Weather problems	2 0.5%	412 13.4%
Contamination	13 3.4%	113 3.7%
Loss of supply	0 0.0%	58 1.9%
Equipment breakdowns	0 0.0%	41 1.3%
Other difficulties	0 0.0%	12 0.4%

*Number and percent of systems have as the base the total number of independent community systems using surface water under the respective headings (some systems used more than one source): SMSA, 374; nonSMSA, 3,065. However, one system might report more than one type of problem. Because of this potential for double counting, numberical and percentage totals are excluded.

month testing was most common: that was the testing interval at about eight of ten systems, whether within or outside of SMSAs.

Although the incidence of testing and the testing interval were similar at SMSA and nonSMSA systems, the types of organizations conducting the tests varied somewhat. The bacteriological tests were most often done by public health departments (Table VII-109), but state environmental departments conducted the tests in about twice as large a proportion of nonSMSA as SMSA systems. On the other hand, private laboratories were used by a much larger proportion of SMSA systems than nonSMSA systems. About nine of ten systems, whether within or outside of SMSAs, had results which met prescribed levels for all tests assessed in the NSA (the number of tests which were assessed varied as explained earlier in the national findings).

— Chemical water quality tests

Chemical tests for water quality were performed in a slightly larger proportion of nonSMSA systems (55.1 percent) than in SMSA systems (47.7 percent). Essentially all of the most recent tests had been done during 1970-78, and the proportion of tests increased greatly during the last two years of that time period—about seven out of eight systems, whether inside or outside of SMSAs, reported that the last test had been done in 1977 or 1978. Results of the tests were not assessed in the NSA for reasons discussed earlier in the national section on chemical water quality tests.

SMSA/nonSMSA variation in test history at households served by independent systems

Water quality tests had been performed at 4.7 percent of the 2.7 million SMSA households served by independent systems, and at 5.9 percent of the 5.8 million nonSMSA households served by independent systems. These proportions

Table VII-109

SMSA/NonSMSA Variation in Organizations Conducting Bacteriological Water Quality Tests for Independent Community Systems

Characteristic	Number and Percent of Systems SMSA	NonSMSA
Organizations Conducting Tests		
Public health department	3,488 64.5%	12,530 57.0%
State environmental department	857 15.8%	7,212 32.8%
Private laboratory	1,007 18.6%	923 4.2%
System laboratory	22 0.4%	503 2.3%
System laboratory and either public health department or state environmental department	25 0.5%	107 0.5%
Public health department and private laboratory	0 0.0%	80 0.4%
Hospital laboratory	0 0.0%	53 0.2%
Federal laboratory	0 0.0%	5 0.0%
Other	11 0.2%	396 1.8%
Could not be determined	0 0.0%	156 0.7%
Total	5,410 100.0%	21,965 99.9%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

were close to the overall proportion of households, served by independent systems, at which testing had been done. Specifically, as reported earlier, tests had been performed at 5.5 percent of the 8.5 million households served by independent community systems.

The frequency of tests in households which did testing generally was similar in SMSA and nonSMSA households. That is, testing had been done no more than twice in most households served by independent systems. However, 30 or more tests had been done at 16.3 percent of SMSA households, as opposed to only 6.3 percent of nonSMSA households. The number of tests was unknown at a much larger proportion of nonSMSA households (17.5 percent) than SMSA households (3.8 percent).

The last test was performed most often to determine if a system alteration were needed. This was the reason for the test in 67.8 percent of SMSA households and in 54.6 percent of nonSMSA households. The second most common reason for the test in SMSA households (in 16.2 percent) was to check the water after a system breakdown. In nonSMSA households (in 14.4 percent) the second most common reason was to check the water after installation of a new water system. Another contrast in the results was that the test was done in 5.8 percent of SMSA households (7,000) because the water was suspected as the cause of someone's illness, but the test was not done for this reason in any nonSMSA household.

The last test at nonSMSA households was requested most often (at 36.2 percent of households) by local, state, or federal officials. At SMSA households, on the other hand, the last test was requested most often (at 44.2 percent) by a household member. The test was requested by a local, state, or federal official at only 25.8 percent of SMSA hosueholds. The test was done as a standard procedure of the system at about 13 percent of the households, whether within or outside of SMSAs.

The data about the type of test performed were difficult to interpret because the type of test was unknown at a large proportion of systems (at about 53 percent of nonSMSA systems and about 33 percent of SMSA systems). Chemical tests were done singly, or in combination with bacteriological tests, at about 50 percent of SMSA households and about 36 percent of nonSMSA households. Bacteriological tests were done singly, or in combination with chemical tests, at about one-third of both SMSA and nonSMSA households.

The results of the bacteriological tests were unknown at about three-quarters of both SMSA and nonSMSA households which had the tests. The results met the applicable standards at the other one-quarter of SMSA and nonSMSA households.

The results of the chemical tests were unknown at about 86 percent of SMSA households, and at the other SMSA households, the results were acceptable for all constituents except iron and chromium. Concentrations of iron and chromium exceeded applicable standards at 9.8 percent of SMSA households (10,000). At nonSMSA households, the results of the chemical tests were unknown at about 87 percent of households which had the tests. The other nonSMSA households had acceptable results for all constituents except calcium. Concentrations of calcium exceeded the standards at 2.0 percent of nonSMSA households (6,000).

Size-of-place variation in independent systems

The largest proportion of independent systems—74.5 percent, or 22,361—served households in other rural areas. The smallest proportion of independent systems—10.2 percent, or 3,061—served households in large rural communities. Finally, 15.3 percent of independent systems (4,606) served households in small rural communities.

For convenience, the systems often will be referred to as large-community systems, small-community systems, and other-rural-area systems. This terminology can be misleading, however, since systems may serve households which are some distance away. Thus, a system located in a large community may serve households in other rural areas, and the reverse also may be true. The designation, therefore, actually refers to the location of the household served, not the location of the system, although in many cases the households and the systems were in the same general area.

Size-of-place variation in size of independent systems

As measured by the number of connections and the length of distribution lines, systems generally were considerably larger if they served households in rural communities as opposed to households in open country. Specifically, in large-community systems, the median number of connections was 543.9, and the median length of distribution lines was 15.3 kilometers (9.5 miles). In small-community systems, the median number of connections was 201.8, and the median length of distribution lines was 7.0 kilometers (4.3 miles). In other-rural-area systems, the median number of connections was 36.9, and the median length of distribution lines was 1.5 kilometers (0.9 miles).

Size-of-place variation in source, ownership, and age of independent systems

Groundwater was the predominant source for independent systems, but surface water was used much more often by larger-community systems than by either small-community systems or other-rural-areas systems. Specifically, surface water was a source at 20.2 percent of large-community systems, but only at 8.6 percent and 10.8 percent of small-community and other-rural-area systems, respectively. Groundwater was a source at 83.0 percent of large-community systems, 91.7 percent of small-community systems, and 90.9 percent of other-rural-area systems. Both groundwater and surface water were sources at 3.2 percent of large-community systems, 0.3 percent of small-community systems, and 1.8 percent of other-rural-area systems.

The ownership of large- and small-community systems implied a more complex, possibly more formal arrangement than existed at other-rural-area systems. As seen in Table VII-110, the largest proportion of systems serving households in large and small communities were owned by public bodies. In sharp contrast, the largest proportion of systems serving households in other rural areas were owned by individuals, and less than 20 percent of all other-rural-area systems were owned by public bodies (although 25.0 percent were owned by private firms).

As to age of the independent systems, determined either by the number of years since original construction or by the number of years since subsequent major alteration, small-community systems tended to be the oldest. Specifically, the median age of small-community systems was 6 years, compared to 3.6 years for large-community systems and 2.4 years for other-rural-area systems.

Size-of-place variation in water usage, maximum design capacity, and metered connections

Just as systems serving large-community and small-community households tended to be considerably larger in terms of number of connections and miles of distribution lines, those systems also tended to have larger operations in terms of daily water usage (production) and daily design capacity. Specifically, the median average daily use of water for systems for which the information was available was 595,030 liters (157,195 gallons) at large-community systems, 186,526 liters (49,276 gallons) at small-community systems, and 69,516 liters (18,365 gallons) at other-rural-area systems. Similarly, the median maximum daily design capacity was 1,876,858 liters (495,828 gallons) at large-community systems, 946,671 liters

Table VII-110

Size-of-Place Variation in Ownership of Independent Community Systems

	Number and Percent of Systems			
Characteristic	Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
Ownership				
Public	11,000	2,521	4,367	4,171
	36.8%	82.4%	94.8%	18.7%
Individual	9,000	0	57	9,357
	31.4%	0.0%	1.2%	41.9%
Private firm	6,000	325	162	5,592
	20.2%	10.6%	3.5%	25.0%
Cooperative	3,000	59	20	2,859
	9.8%	1.9%	0.4%	12.8%
Indian tribe	200	0	0	248
	0.8%	0.0%	0.0%	1.1%
Other	10	0	0	5
	0.0%	0.0%	0.0%	0.0%
Could not be determined	300	156	0	129
	0.9%	5.1%	0.0%	0.6%
Total	30,000	3,061	4,606	22,361
	100.0%	100.0%	99.9%	100.1%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

(250,092 gallons) at small-community systems, and 327,450 liters (86,507 gallons) at other-rural-area systems.

Metering also was more extensive at systems serving households in large or small communities. For example, connections were metered by about 88 percent of all large-community systems, and about 80 percent of these systems metered 95 percent or more of all connections. Connections were metered by about 73 percent of all small-community systems, and about 59 percent of these systems metered 95 percent or more of all connections. Finally, only 43 percent of other-rural-area systems metered connections, and about 40 percent of these systems metered 95 percent or more of all connections.

Size-of-place variation in facilities for distributing and treating water

In keeping with their larger size and operation, systems serving large-community and small-community households, as opposed to those serving other-rural-area households, more often had originally installed treatment plants and storage tanks. Originally installed treatment plants were reported at 57.4 percent of 472 large-community systems and at 52.8 percent of 1,045 small-community systems. In contrast, originally installed treatment plants were reported at only 37.4 percent of 7,649 other-rural-area systems. Similarly, 90.0 percent and 68.9 percent of large-community systems and small-community systems, respectively, had originally installed storage tanks. In contrast, 52.4 percent of other-rural-area systems had the storage tanks.

Other-rural-area systems, however, did more often have originally installed pressure tanks. Specifically, no large-community systems had the tanks, only 6.4 percent of the small-community systems had the tanks, and 12.8 percent of other-rural-area systems had the tanks. This finding was consistent with the relative size of the systems, since the pressure tanks would have been more useful in the smaller systems serving other rural areas than in the larger systems serving communities. Larger systems generally would require storage tanks or reservoirs.

Although other-rural-area systems lagged behind in the extent of originally installed facilities, this was not always true for equipment added later during major alterations. Among the systems which reported major alterations (and which therefore did not report original-construction equipment), treatment plants had been added at 26.0 percent of 2,589 large-community systems, 19.0 percent of 3,561 small-community systems, and 22.5 percent of 14,701 other-rural-area systems. Storage tanks had been added at a larger proportion of other-rural-area systems (35.2 percent) than at large-community systems (32.6 percent) or small-community systems (29.7 percent). Similarly, pumps had been added at 53.5 percent of other-rural-area systems compared to 39.6 percent of large-community systems and 28.2 percent of small-community systems. Wells had been added at 37.5 percent of small-community systems, compared to 34.8 percent and 28.6 percent of large-community systems and other-rural-area systems, respectively. On the other hand, reservoirs had been put into service at 15.0 percent of other-rural-area systems, three times the proportion at either large-community systems or small-community systems.

Water generally was treated more extensively at systems serving households in large communities and small communities than at systems serving households in other rural areas. Some type of treatment was practiced at 77.2 percent of large-community systems, 81.6 percent of small-community systems, and only 54.0 percent of other-rural-area systems. As seen in Table VII-111, the trend toward more extensive treatment in systems serving community households sometimes was very pronounced. For example, chlorination was practiced considerably more often at systems serving community households than at systems serving other-rural-area households, and chlorinators were in operation at a larger proportion of the former systems, particularly those serving large-community

Table VII-111

Size-of-Place Variation in Treatment Processes and Treatment Devices for Independent Community Systems

	Number and Percent of Systems**			
Characteristic*	Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
Treatment Processes				
Chlorination	17,000 57.5%	2,267 74.1%	3,556 77.2%	11,456 51.2%
Filtration	4,000 14.1%	833 27.2%	888 19.3%	2,503 11.2%
Fluoridation	2,000 6.5%	490 16.0%	728 15.8%	745 3.3%
Softening	2,000 6.0%	210 6.9%	470 10.2%	1,107 5.0%
Aeration	600 2.1%	149 4.9%	247 5.4%	236 1.1%
Coagulation	500 1.6%	166 5.4%	38 0.8%	264 1.2%
Flocculation	300 1.0%	63 2.1%	33 0.7%	191 0.9%
Other treatment processes	2,000 6.2%	239 7.8%	862 18.7%	774 3.5%

Table VII-111 continued

Characteristic*	Number and Percent of Systems** Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
Treatment Devices in Operation				
Chlorinator	14,000 47.7%	2,160 70.6%	2,683 58.3%	9,492 42.4%
Chemical feeder unit	3,000 10.8%	979 32.0%	710 15.4%	1,567 7.0%
Filter	3,000 9.3%	639 20.8%	724 15.6%	1,427 6.4%
Fluoridator	2,000 6.4%	480 15.7%	675 14.7%	752 3.4%
Softener	2,000 5.8%	182 5.9%	409 8.9%	1,159 5.2%
Settling tank	1,000 4.0%	305 10.0%	179 3.9%	725 3.2%
Aerator	400 1.2%	140 4.6%	147 3.2%	84 0.4%
Other treatment devices	700 2.4%	89 2.9%	490 10.6%	154 0.7%

*Data are for systems having at least one process or device, as indicated; some systems may have had more than one of each.

**Percentages are of the total number of independent community systems: nation, 30,000; large rural communities, 3,061; small rural communities, 4,606; other rural areas, 22,361.

households. Filtration and fluoridation also were more common at systems serving community households than at systems serving other-rural-area households, and filters and fluoridators were in operation at a larger proportion of the former households.

Overall, treatment appeared to be slightly more extensive at large-rural-community systems than at small-rural-community systems, particularly in regard to the proportion of systems with treatment devices actually in operation at the time of the NSA. In fact, the proportion of large-rural-community systems with operating devices was larger than the proportion of small-rural-community systems with operating devices for all equipment except softeners and other treatment devices.

Size-of-place variation in system operators

The larger operation at systems serving large-community households apparently required greater manpower than the operations at systems serving households in small communities or in other rural areas. For example, about 90 percent of large-community systems had five or fewer operators, whereas about 90 percent of small-community systems and other-rural-area systems had only three or fewer operators. The median number of operators at large-community systems (less than two), however, was very close to the median number of operators at small-community systems and at other-rural-area systems (less than one in either group of systems).

As seen in Table VII-112, large-community systems also relied to a much greater degree on paid, full-time operators than did systems in the other two size-of-place categories. Conversely, the large-community systems relied infrequently on volunteers. Paid, part-time help in operating equipment occurred most often at small-community systems.

Table VII-112

Size-of-Place Variation in Work Status of Operators at Independent Community Systems

Characteristic	Number and Percent of Systems			
	Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
Status of Operators*				
Volunteer	7,000 25.0%	19 0.6%	687 15.1%	6,296 31.0%
Paid part-time	14,000 50.0%	1,341 45.8%	2,539 55.8%	9,618 47.4%
Paid full-time	10,000 35.7%	1,993 68.0%	1,910 42.0%	6,410 31.6%

*The percent of systems refers to the proportion of those systems which had at least one operator in the respective categories; the bases are the numbers of systems which had at least one operator: for the nation, about 28,000; for large-rural-community systems, 2,933; for small-rural-community systems, 4,547; for other-rural-area systems, 20,284. In a system with several operators, each operator could be in a different status category, and the column totals thus exceed the total numbers of systems which had at least one operator.

In addition, large-community systems were much more likely than systems in the other two categories to have at least one operator with special training in using equipment at the system. At least one operator with such training was reported at 70.1 percent of all large-community systems, at 55.1 percent of all small-community systems, and at 42.8 percent of all other-rural-area systems. Although large-community systems were more likely to have at least one specially-trained operator, some other-rural-area systems had more such operators than systems in the other two categories. Specifically, no large-community system or small-community system had more than ten specially trained operators, whereas 154 other-rural-area systems (0.7 percent of all other-rural-area systems) had more than ten specially trained operators. Despite these differences, the degree of special training was similar at systems in the three different size-of-place categories. Specifically, special training had been given to all operators at 27.0 percent of large-community systems, 27.7 percent of small-community systems, and 25.1 percent of other-rural-area systems. However, special training had been given to exactly one-half of the operators at 13.8 percent of large-community systems, 16.1 percent of small-community systems, and only 6.9 percent of other-rural-area systems.

In keeping with the larger operation at large-community systems, the amount of labor required was much greater at large-community systems than at systems in the other two categories. Specifically, excluding the systems for which information was not available, the median number of man-days per month was 18.3 at large-community systems, 7.2 at small-community systems, and only 1.4 at other-rural-area systems.

To summarize the size-of-place findings to this point, the overall operation was much more extensive at systems serving rural community households than at systems serving other-rural-area households. The operation was particularly extensive at large-community systems. In fact, as determined by most characteristics—number of connections, length of distribution lines, daily average water usage, daily design capacity, and man-hours required each month—the large-community systems were much larger than even the small-community systems. Roughly, as calculated by comparing the medians for each of these characteristics, the large-community systems were approximately two and one-half times larger than the small-community systems. In turn, as measured by the same criteria, the small-community systems were from two to five times larger than the other-rural-area systems.

Systems serving community households also were distinguished by other characteristics. For example, water was more likely to receive some type of treatment—particularly chlorination, filtration, and fluoridation—at large-community systems and at small-community systems than at other-rural-area systems. Metering also was much more common in systems serving community households than in systems serving other-rural-area households. Finally, the proportion of systems serving community households which were owned by public bodies or private firms (more than 90 percent, combined) was twice the proportion of other-rural-area systems which had that type of ownership. In contrast, about 42 percent of other-rural-area systems were owned by individuals, whereas only 1.2 percent and 0.0 percent of small-community systems and large-community systems, respectively, were owned by individuals.

The NSA profile, then, highlighted the systems serving households in communities, as opposed to those serving households in other rural areas, as being the more complex, probably more formal organizations. In short, the operations of the former systems—whether extraction, treatment, or distribution—were larger and more intricate. The ownership of the former systems implied formal business arrangements which may have been lacking in the other-rural-area systems, more than 40 percent of which were owned by individuals.

Size-of-place variation in system performance

Despite the prominent difference in their characteristics, systems serving households in different size places tended to have the same record in terms of breakdowns during the previous year. That is, at least one breakdown had occurred at 53.9 percent of all large-community systems (information was not available at 1.4 percent). Similarly, breakdowns had occurred at 50.5 percent of all small-community systems (information was not available at 0.5 percent). Finally, breakdowns were reported at 55.7 percent of other-rural-area systems (information was not available at 1.6 percent).

Breakdowns resulted in interruption of service somewhat less often in large-community systems than in systems in the other two size-of-place categories. Specifically, interruption of service occurred at 62.6 percent of the 1,649 large-community systems which had at least one breakdown. In comparison, interruption occurred at 68.9 percent of the 2,324 small-community systems which had at least one breakdown, and at 70.6 percent of the 12,436 other-rural-area systems which had at least one breakdown. Information was not available for a small proportion of all systems, ranging from 0.6 percent of small-community systems through 2.3 percent of large-community systems.

As seen in Table VII-113, reasons for the breakdowns differed according to the size-of-place categories. The most prominent reasons were pump malfunctions and ruptured lines, but whereas pump malfunctions were cited most often in other-rural-area systems and small-community systems, ruptured lines were cited most often in large-community systems. Breakdowns due to adjustment for the pH level of the water were much more common in systems serving households in communities than in systems serving households in other rural areas.

As to difficulties in acquiring water from the source, the overall problem was slightly more prevalent in large-community systems (in 16.3 percent of those systems) than in small-community systems or in other-rural-area systems (in 12.6

Table VII-113

Size-of-Place Variation in Reasons for Breakdowns in Independent Community Systems During Previous Year

Characteristic	Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
	Number and Percent of Systems*			
Reasons for Breakdowns				
Pump malfunction	8,000 51.5%	450 27.3%	1,010 43.5%	6,997 56.3%
Ruptured lines	8,000 50.2%	1,015 61.6%	1,026 44.1%	6,209 49.9%
Power failure	2,000 14.6%	230 13.9%	169 7.3%	2,001 16.1%
Adjustment for pH level of water	2,000 12.0%	374 22.7%	661 28.4%	943 7.6%
Treatment equipment malfunction	400 2.3%	30 1.8%	93 4.0%	261 2.1%
Flooding	70 0.4%	25 1.5%	30 1.3%	15 0.1%
Drought	50 0.3%	45 2.7%	0 0.0%	7 0.0%
Vandalism	10 0.0%	0 0.0%	0 0.0%	6 0.0%
Other reasons	1,000 6.9%	80 4.9%	287 12.3%	775 6.2%

*Numbers and percentages refer to the systems which had at least one breakdown: in the nation, about 16,000; large-community systems, 1,649; small-community systems, 2,324; other-rural-area systems, 12,436. However, one system may have given several reasons for one breakdown, and thus may have been tallied separately for each of several reasons. As a result, the total number of systems under each table heading exceeds the total number which had at least one breakdown.

percent and 11.6 percent of those systems, respectively). When the type of source was considered, difficulties were proportionately associated more often with surface water than with groundwater in large-community systems and in other-rural-area systems—but not in small-community systems. Specifically, 11.4 percent of large-community systems (290) which used groundwater sometimes had difficulty obtaining water from that source, whereas 33.6 percent of large-community systems (208) which used surface water sometimes had difficulties. Similarly, only 9.2 percent of other-rural-area systems (1,873) which used groundwater sometimes had difficulties with that source, whereas 33.3 percent of other-rural-area systems (808) which used surface water sometimes had difficulties. In contrast, 13.8 percent of small-community systems (581) which used groundwater sometimes had difficulties, whereas only 9.3 percent of small-community systems (37) which used surface water had difficulties.

The specific types of difficulties with groundwater were proportionately similar in each size-of-place category. The proportions were all within three percentage points of those listed for the nation as a whole in Table VII-99. The specific difficulties with surface water, on the other hand, varied somewhat according to the size-of-place categories, as seen in Table VII-114. In particular, difficulties caused by insufficient quantity were about four times more prevalent in systems serving other rural areas than in systems serving communities. Weather problems such as flooding or drought caused difficulties most frequently at large-community systems, and (at least in the NSA survey) never at small-community systems.

Size-of-place variation in water test history at independent community systems — Bacteriological water quality tests

Bacteriological testing was done at about nine of ten systems serving households in large communities or households in other rural areas, and at all

Table VII-114

Size-of-Place Variation in Difficulties in Obtaining Water for Independent Community Systems Using Surface Water

Difficulties	Number and Percent of Systems*			
	Nation	Large Rural Communities	Small Rural Communities	Other Rural Areas
Surface Water				
No difficulties	2,300 66.9%	411 66.4%	360 90.7%	1,616 66.7%
Insufficient quantity	600 17.8%	35 5.7%	21 5.3%	557 23.0%
Weather problems	400 12.0%	152 24.6%	0 0.0%	262 10.8%
Contamination	100 3.7%	14 2.3%	0 0.0%	112 4.6%
Loss of supply	60 1.7%	7 1.1%	21 5.3%	30 1.2%
Equipment breakdowns	40 1.2%	25 4.0%	16 4.0%	0 0.0%
Other difficulties	10 3.5%	12 1.9%	0 0.0%	0 0.0%

*Number and percent of systems have as the base the total number of independent community systems using surface water under the respective headings (some systems used more than one source): nation, about 3,000; large-community systems, 619; small-community systems, 397; other-rural-area systems, 2,424. However, one system might report more than one type of problem. Because of this potential for double counting, numerical and percentage totals are excluded.

systems serving households in small communities. Once-a-month testing was most common: that was the testing interval at about eight of ten systems, regardless of their size-of-place classification.

The proportions of most organizations conducting the tests in systems in each of the three size-of-place categories were similar to the proportions for the nation as a whole (see Table VII-100). The only exception was that three types of organizations—federal laboratory, hospital laboratory, and the combination of public health department and private laboratory—although relatively small in number, did the testing only for systems serving households in other rural areas. About nine of ten systems, regardless of the size-of-place classification, had results which met prescribed levels for all tests assessed in the NSA (the number of tests which were assessed varied, as explained earlier in the national findings).

— Chemical water quality tests

Chemical tests for water quality were performed more often among large-community systems (73.2 percent) than among small-community systems (61.0 percent) or other-rural-areas systems (49.5 percent). The information could not be obtained at from about 7 percent of systems (small-community systems) through about 10 percent of systems (other-rural-area systems). Nearly all of the most recent chemical tests had been performed during 1970-78, regardless of the systems' size-of-place classification. The proportion of tests increased at all systems during 1975-78, particularly at systems serving community households. The sharpest increase occurred during the last two years, when tests were done at 87.9 percent of large-community systems, 87.7 percent of small-community systems, but at only 65.7 percent of other-rural-area systems. Results of the tests were not assessed in the NSA for reasons discussed earlier in the national section on chemical water quality tests.

Size-of-place variation in test history at households served by independent systems

Water quality testing was more common at community households—particularly small-community households—served by independent systems than at other-rural-area households. Specifically, tests had been done at 6.0 percent of 1.9 million large-community households, 12.2 percent of 1.1 million small-community households, and 4.0 percent of 5.5 million other-rural-area households.

Although testing was done in a smaller proportion of other-rural-area households served by independent systems, the frequency of testing tended to be somewhat greater in other-rural-area households. Specifically, only one test had been done at 89.9 percent of the large-community systems at which testing had been done, and the information could not be obtained at the other 10.1 percent. Ten or fewer tests had been performed at 67.6 percent of the small-community households at which testing had been done, but information could not be obtained at 28.3 percent. Fewer than ten tests had been done at 69.7 percent of other-rural-area households at which testing had been accomplished, but twenty or more tests had been performed at 18.1 percent; information could not be obtained at 12.2 percent.

The last test invariably was performed most often to determine if a system alteration was needed. This was the reason in 59.5 percent of large-community households, 65.5 percent of small-community households, and 52.7 percent of other-rural-area households. Checking the water after installation of a new system was the second most common reason at small-community households (8.2 percent) and at other-rural-area households (15.0 percent). However, checking the water after a natural disaster such as flooding was the second most common reason at large-community households (11.0 percent), although this reason was not given at households in the other two size-of-place categories. Three other reasons for the test were given only at other-rural-area households: to check the water after a system breakdown (at 9.2 percent of households), to test the water after a system alteration (at 7.2 percent of households), and to check the water because of illness which was suspected to be related to the water (at 3.3 percent of the households).

The last test at small-community households and at other-rural-area households was requested most often by local, state, or federal officials (at 39.1 percent of the former households and at 31.5 percent of the latter). Although such officials requested the test at 30.3 percent of large-community households, someone from the household asked for the test at 44.8 percent of those households. A contractor requested the test at 9.1 percent of large-community households and at 17.1 percent of small-community households, but at none of the other-rural-area households. The information was available at all large-community households, but not at 17.9 percent of other-rural-area households nor at 11.8 percent of small-community households.

As was true for SMSA and nonSMSA households, the type of test performed was unknown at large proportions of households in each size-of-place category. Specifically, among households at which testing was done, the type of test was not known at 41.1 percent of large-community households, 49.2 percent of small-community households, and 50.2 percent of other-rural-area households. This situation hindered interpretation of the data about the type of test, especially since tests had been performed at only 5.5 percent of households served by independent systems. Despite this qualification, the pattern for the type of test was distinctive for households in each size-of-place category. In large-community households, chemical tests predominated (at 45.0 percent), while bacteriological tests (at 3.0 percent) or a combination of chemical and bacteriological tests (at 11.0 percent) were much less frequent. In small-community households, chemical tests were done at 17.8 percent of households, bacteriological tests at 3.0 percent of households, and a combination of tests at 30.1 percent of households. Whereas chemical tests or a combination of chemical and bacteriological tests were most common at large-community households and small-community households, bacteriological tests were most common at other-rural-area households (at 23.3 percent). Chemical tests were done only at 6.6 percent of other-rural-area households, a combination of tests was done at 19.9 percent of those households, and bacteriological tests were done at 23.3 percent of households.

The results of the bacteriological tests at households in the different size-of-place categories were unknown at from 70.4 percent of households (at other-rural-area households which did the tests) through 94.6 percent of households (at large-community households which did the tests). The results met the applicable standards at the other households in each of the size-of-place categories.

The results of the chemical tests were unknown at about 94 percent of large-community households, and at the other large-community households the results were acceptable for all constituents except iron and chromium. Concentrations of iron and chromium exceeded applicable standards at 9.3 percent of large-community households (10,000). At small-community households, the results of the chemical tests were unknown at about 82 percent of households which had the tests, and the results were acceptable for all constituents at the other households. At other-rural-area households, the results of chemical tests were not known at about 87 percent of households. The other-rural-area households at which results were known had acceptable results for all constituents except calcium. Concentrations of calcium exceeded the standards at 3.6 percent of the other-rural-area households (6,000).

Consolidated systems

As already noted, consolidated community systems—with their unique attributes—were greatly outnumbered by independent community systems. On the other hand, the consolidated systems tended to be much larger than the independent ones in terms of number of connections. Whereas the median number of connections for the 30,000 independent systems was about 59, the median number of connections for the 4,000 consolidated systems was about 153—two and one-half times the number for the independent systems. At the same time, two independent community systems each had 90,000 or more connections, about twice as many as the largest consolidated system (which had 46,000 connections). To put these seemingly contradictory findings into perspective, the two very large independent systems represented less than 0.1 percent of all of the independent systems. All of the rest each had 30,000 or fewer connections. All of the consolidated systems, except for the one with 46,000 connections, also had 30,000 or fewer connections. In other words, most of the community systems, whether consolidated or independent, had no more than 30,000 connections. In fact, about 90 percent of all consolidated systems had 800 or fewer connections; about 90 percent of all independent systems had 520 or fewer connections. Looked at another way, although the consolidated community systems tended to be very large in terms of systems serving rural America, they still were quite small in comparison with many urban systems.

In terms of the length of the distribution lines (including main lines but excluding service lines), consolidated systems also tended to be considerably larger than independent ones. Specifically, excluding the 450 consolidated systems (11.3 percent) for which the information could not be obtained, the median length of consolidated-system distribution lines was about 4.3 kilometers (2.8 miles). Although this length was not large in comparison to that in urban systems serving 10,000 persons or more,[32] it was more than one and one-half times the median length of independent-system distribution lines (2.4 kilometers, or 1.5 miles). About 54 percent (2,200) of all consolidated systems had ten kilometers (6.2 miles) or less of lines, and 79.5 percent (3,200) had 160 kilometers (99.4 miles) or less of lines. About 9 percent (370) of consolidated systems had lines which ranged from 160 kilometers up to the limit of the NSA recording capacity (10,000 kilometers, or 6,000 miles). Information was not available for 11.3 percent of the systems (450).

Although the consolidated systems clearly tended to have larger distribution networks than the independent systems, NSA investigators had anticipated that the difference would be even greater. The reason was that since nearly 90 percent of all of the consolidated systems used purchased water as at least one source (see Table VII-115), it was expected that long-distance transmission of purchased water from the selling to the purchasing facility would be common. There were four possible explanations for the unexpected NSA findings. The first was that the selling and purchasing facilities were much closer geographically than had been envisioned. The second was that since the length of transmission lines carrying water from the source to the facility was not supposed to be included in the total length of the distribution lines (defined as main and distribution pipes between the facility and the customers), the NSA data may not have included that information for systems purchasing water. The third was that since the population of community systems was dominated by smaller systems with less than 100 connections, the bulk of smaller systems determined the median length of distribution lines; therefore, the average (mean) length of distribution lines would better reflect the influence of large community systems such as the consolidated ones which purchased water. Finally, the size of consolidated systems may have been artificially reduced in the NSA data since the data may have referred to the subsystem serving the sampled rural households rather than to the entire consolidated system. As explained in the introduction to "community systems" in this chapter, it was not possible to determine the extent of this influence on the NSA findings.

Source, ownership, and age of consolidated systems

As seen in Table VII-115, purchased water is by far the most common source for consolidated community systems. Although some systems (a total of about 500, or about 11 percent of the total number of consolidated systems) used

Table VII-115

Source, Ownership, and Age of Consolidated Community Systems

Characteristic	Nation Number of Systems	Nation Percent of Systems
Source		
Groundwater	800*	18.9*
Surface water	300	7.9
Purchased water	3,500	87.8
Ownership		
Public	1,900	48.7
Individual	1,200	31.9
Private firm	500	13.4
Cooperative	200	4.0
Could not be determined	80	2.1
Total	4,000	100.1
Age (number of years since construction or alteration)		
Less than 1	500	13.5
1 - 5	1,200	30.1
6 - 10	1,600	40.4
11 - 15	200	5.9
16 - 20	30	0.7
21 - 50	100	3.6
More than 50	30	0.7
Continuous improvements	30	0.7
Could not be determined	200	4.6
Total	4,000	100.2

*Since some systems used more than one source, the total number of systems is greater than 4,000 and the total percentage is greater than 100.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

more than one source of water, purchased water was the predominant source. As a result, the organizational, administrative, and technological features peculiar to purchased-water systems had a decisive influence on the data for the consolidated community systems.

Those systems were most often owned by a public body. In fact, proportionately more consolidated than independent systems (48.7 percent, compared to 36.8 percent) were owned by the public. This indicated a trend away from private ownership by firms or individuals, and toward public ownership.

Both independent and consolidated community systems appeared to have more complex, perhaps more formal, organizational structures (based on ownership) than did intermediate systems. That is, about 66 percent of either consolidated or independent systems were owned by public bodies, private firms, or cooperatives. In contrast, about 91 percent of intermediate systems were owned by individuals. Thus, the NSA data pointed to a sharp transition between intermediate and community systems. The former often were the responsibility of one individual owner. The latter were more often organized within the framework of a firm or cooperative.

As to the age of the consolidated systems, 84 percent had been built or had received a major alteration within the preceding ten years (Table VII-115). Within this definition of "age," the median age of consolidated systems was 5.5 years —compared to seven years for intermediate systems and three years for independent community systems. As was true for intermediate and independent systems, a small proportion (0.7 percent) of consolidated systems were categorized as having "continuous improvements." This meant that major alterations were done on a routine, ongoing basis in these systems. The "continuous improvements" category was the equivalent of an age of less than one year, since improvements had been made during the year of the NSA study.

Water usage, maximum design capacity, and metered connections

In terms of water usage and maximum design capacity (Table VII-116), the consolidated systems again demonstrated larger operations than those at independent systems. For the 3,500 consolidated systems for which water use information was available, the median average daily use of water was about 162,000 liters (42,797 gallons) during the year preceding the NSA. By comparison, the median average daily use of water in the independent systems was about 136,000 liters (35,928 gallons), as reported above. The median maximum daily design capacity for the 2,000 consolidated systems for which information was available was about 719,000 liters (189,945 gallons). This was about one and one-quarter times the maximum design capacity of the independent systems. In addition, the ranges for both average daily use of water and maximum design capacity were larger for consolidated than for independent systems (compare Tables VII-116 and VII-95).

Another distinction between consolidated and independent systems was that the former tended to have a larger proportion of metered connections to determine the amount of water used by customers. About 74 percent of all consolidated community systems, compared to only about 52 percent of independent systems, metered some connections. As was true for independent systems, most consolidated systems which did meter connections did so for 95 percent or more of the connections. The overall percentage of consolidated community systems (about 73 percent) doing this degree of metering, however, exceeded the percentage of independent systems (about 47 percent) doing this much metering.

To summarize the findings to this point, the consolidated systems were found to be substantially larger enterprises, in terms of certain measurements of size and capacity, than were independent systems. The consolidated systems, based on median values, tended to have far more connections, larger distribution networks, greater daily water production, and larger maximum daily design capacity. In terms of the overall profile of multiple-connection rural systems

Table VII-116

Average Daily Use and Maximum Daily Design Capacity of Consolidated Community Systems

		Nation	
Quantity in Liters	Approximate Quantity in Gallons	Number of Systems	Percent of Systems
Average Daily Use (during year preceding the NSA)			
1,000 - 5,000	264 - 1,320	20	0.5
5,001 - 50,000	1,321 - 13,200	1,200	29.0
50,001 - 100,000	13,201 - 26,418	200	4.1
100,001 - 200,000	26,419 - 52,836	900	22.3
200,001 - 300,000	52,837 - 79,254	100	3.6
300,001 - 500,000	79,255 - 132,090	300	6.6
500,001 - 1,000,000	132,091 - 264,180	400	9.5
1,000,001 - 2,000,000	264,181 - 528,360	100	2.9
2,000,001 - 5,000,000	528,361 - 1,320,900	100	2.2
5,000,001 - 10,000,000	1,320,901 - 2,641,800	100	2.3
10,000,001 - 20,000,000	2,641,801 - 5,283,600	20	0.6
20,000,001 - 100,000,000	5,283,601 - 26,418,000	200	4.3
100,000,001 - 1,200,000,000	26,418,001 - 317,000,000	10	0.2
Could not be determined		500	12.0
Total		4,000	100.1
Maximum Daily Design Capacity			
30,000 - 250,000	7,925 - 66,045	300	8.0
250,001 - 500,000	66,046 - 132,090	600	14.1
500,001 - 1,000,000	132,091 - 264,180	100	3.6
1,000,001 - 2,000,000	264,181 - 528,360	200	4.3
2,000,001 - 3,000,000	528,361 - 792,540	100	2.1
3,000,001 - 5,000,000	792,541 - 1,320,900	100	2.7
5,000,001 - 10,000,000	1,320,901 - 2,641,800	200	5.2
10,000,001 - 100,000,000	2,641,801 - 26,418,000	100	3.3
100,000,001 - 2,220,000,000	26,418,001 - 586,000,000	200	4.3
Could not be determined		2,000	52.4
Total		4,000	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

(based on median values), the consolidated community systems generally were at the extreme in size range for systems serving rural America; the independent community systems were fairly close behind; and the intermediate systems were far behind. At the same time, the ownership of both the consolidated and independent systems appeared to reflect a more complex, seemingly more formal organizational structure than that which existed for intermediate systems. In addition, the organization and facilities of most consolidated systems had to accommodate purchased water arrangements.

Facilities for distributing and treating water

The profile of the major water distribution and treatment facilities at consolidated systems was developed in the same way as the profile for independent systems. That is, first, relevant facilities installed either during initial construction of the system or during subsequent alteration were assessed. Second, specific items of equipment used to treat water at the time of the survey were inventoried.

As to the first step, it was assumed for consolidated systems (as it was for independent ones) that original-construction equipment included essentials such as distribution lines, water sources, and pumps. In addition to those items, certain other units were reported at the 1,800 consolidated community systems which had had no subsequent major alteration at the time of the NSA, and which therefore reported only equipment installed at original construction. The NSA findings showed that, excluding 80 systems (among the 1,800) for which information could not be obtained, 1,500 had storage tanks, 100 had treatment facilities, twenty had reservoirs or dams, and ten had other facilities.

As to the 2,100 consolidated community systems which reported major alterations (and which therefore did not report original-construction equipment), service lines were the main items of equipment which had been added at a substantial number of systems. Specifically, excluding 60 systems (among the

2,100) for which information could not be obtained, 1,600 had added service lines, 500 had added storage tanks, 500 had added pumps, 300 had added wells or made well improvements, 200 had added treatment facilities, 200 had added reservoirs or dams, 20 had added pressure tanks, and 100 had added other facilities.

As to treatment processes in use at the time of the survey, a comparison of the data in Tables VII-117 and VII-96 shows that the major processes (chlorination, filtration, fluoridation, and softening) which received emphasis at the consolidated community systems also received emphasis at the independent systems. The most striking difference was that whereas nearly 40 percent of all independent community systems did not treat their water at all, only about 5 percent of consolidated systems (a total of 200) reported using untreated water. The difference may in large part have been determined by treatment practices at the facilities which sold water within consolidated community systems: all of the systems using purchased water were classified in the NSA as consolidated systems.

Although about 95 percent of consolidated community systems treated water, those systems did not always have functioning devices needed for the various treatment processes. For example, as shown in Table VII-117, chlorination was reported at nearly 92 percent of consolidated systems, but operating chlorinators were reported at only about 64 percent of the systems. Gaps also existed between reported treatment processes and relevant operational equipment in terms of fluoridation, softening, and probably filtration.

System operators

The consolidated community systems were staffed operationally at a higher level than either intermediate or independent systems. About 96 percent of all consolidated systems had at least one equipment operator (Table VII-118), compared to about 93 percent of all independent systems and about 65 percent of all intermediate systems. Furthermore, about 79 percent of consolidated community

Table VII-117

Treatment Processes and Treatment Devices for Consolidated Community Systems

Characteristic*	Nation Number of Systems	Nation Percent of Systems**
Treatment Processes		
Chlorination	3,600	91.9
Filtration	1,800	44.7
Fluoridation	900	21.5
Softening	600	14.4
Coagulation	500	12.3
Flocculation	300	8.7
Aeration	100	2.5
Other treatment processes	200	3.9
Treatment Devices in Operation		
Chlorinator	2,500	63.6
Chemical feeder unit	1,400	35.9
Filter	1,290	31.7
Fluoridator	700	16.6
Settling tank	600	14.0
Softener	500	11.8
Aerator	100	2.4
Other treatment devices	20	0.5

*Data are for systems having at least one process or device, as indicated; some systems may have more than one of each.

**Percentages are of the total number of consolidated community systems (4,000).

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-118

Number and Work Status of Operators in Consolidated Community Systems

Characteristic	Nation Number of Systems	Nation Percent of Systems
Number of Operators		
0	200	3.9
1	700	17.4
2	1,300	31.8
3	1,300	31.6
4	200	3.9
5 - 10	300	6.8
11 - 20	20	0.3
21 - 50	200	4.2
More than 50	10	0.2
Total	4,000	100.1
Status of Operators*		
Volunteer	90	2.4
Paid part-time	2,500	65.8
Paid full-time	1,700	44.7

*A total of about 3,800 systems had at least one operator; in a system with several operators, however, each operator could be in a different status category, and the column total thus exceeds 3,800. The percent of systems here refers to the proportion of the 3,800 systems which had at least one operator in the respective categories.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

systems had two or more operators, compared to about 49 percent of independent systems and 16 percent of intermediate systems. Another indication of the higher staffing level in consolidated systems was the proportion of systems with 21 through 50 operators: 4.2 percent of consolidated systems had that many operators, compared to only 0.8 percent of independent systems (intermediate systems used a maximum of five operators).

The work status of operators in consolidated systems also indicated a more formal organizational arrangement than in independent or in intermediate systems. Only 2.4 percent of consolidated systems had volunteer operators, compared to 25 percent of independent systems and to 86 percent of intermediate systems. On the other hand, nearly 66 percent of consolidated systems had at least one paid part-time operator and nearly 45 percent had at least one paid full-time operator (the percentages total more than 100 since a given system could have several operators with different work status).

Although a greater proportion of consolidated than independent systems had part-time or full-time paid operators, this did not mean that the consolidated systems were more likely to have operators with special training or schooling in the operation of equipment. In fact, about 41 percent of consolidated systems —compared to 45 percent of independent systems—had operators with such training. (In sharp contrast, only 3 percent of intermediate systems had specially trained operators.) About 15 percent of all 4,000 consolidated systems had one operator who had received special training, and about 26 percent had two or more operators who had had such training; about 2 percent of the systems could not provide information on the subject. Thus, although a slightly larger proportion of consolidated than independent systems had operators with no special training, a larger proportion of consolidated systems (about 26 percent) than independent systems (about 16 percent) had two or more operators with such training. In other words, the consolidated systems were slightly less likely than the independent systems to have specially trained operators, but those consolidated systems with such operators were more likely to have several of them rather than just one.

The last finding probably was primarily a reflection of the higher staffing level at the consolidated systems rather than an indication of more inclusive special training. That is, the consolidated systems generally had more operators than did the independent systems, and the degree of training within the two classes of community systems was fairly similar. Specifically, all of the operators at about 20 percent of consolidated and at approximately 26 percent of independent systems had had special training. Half of the operators had had special training at about 9 percent of both classes of systems.

Consistent with the higher operational staffing level in consolidated versus independent systems, the consolidated systems required more labor time for their operation. Excluding the systems for which information was not available, the median man-days per month required to operate consolidated systems was 6.5—or four times the median for independent community systems. (A man-day was equivalent to the work of one person during eight hours.) Also, about 85 percent of consolidated community systems required 140 man-days, or less, of work to operate each month, whereas approximately 85 percent of independent systems required much less labor—50 man-days or less each month.

Overall, then, the finding that consolidated community systems required more labor time to operate than did independent community systems was consistent with other NSA findings differentiating the two classes of systems. That is, the consolidated systems were notably larger operations in terms of size (number of connections), capacity, metering, and daily water production. Concurrently, the consolidated systems also used more operators and more labor time than did the independent systems.

System performance

As was true for other systems, a major purpose of the complex of equipment and manpower at consolidated systems was to provide reliable service to customers. This was assessed in terms of the number of system breakdowns during the preceding year, and in terms of the number of difficulties such as equipment problems, weather problems, or other conditions which interfered with the acquisition of water from the source.

As to breakdowns, about 50 percent of consolidated community systems had breakdowns during the preceding year (Table VII-119). This proportion was slightly smaller than for independent systems (55 percent), but still considerably greater than for intermediate systems (26 percent). The majority of consolidated systems which did have breakdowns had five or fewer.

In terms of the seriousness of the breakdowns (not tabulated in Table VII-119), 88.3 percent (about 1,800) of the 2,000 consolidated systems which had breakdowns reported that at least one of the breakdowns resulted in loss of service to customers. In comparison, about 70 percent of independent community systems with breakdowns reported at least one incidence of loss of service. About 70 percent of the consolidated systems, compared to about 64 percent of independent systems, had fewer than ten such loss-of-service episodes. About the same proportion of consolidated versus independent systems (0.4 percent compared to 0.3 percent) had more than 95 breakdowns resulting in loss of service.

As to reasons for the breakdowns, ruptured lines and pump malfunctions were among the leading causes at consolidated systems, as they were at intermediate and independent systems (Table VII-119). At the same time, the need to make adjustments for the pH level of water became a much more prominent cause of breakdowns for consolidated systems than it had been for independent ones. The technical aspects of this problem were described previously in the report on the independent community systems.

Table VII-119

Frequency and Reasons for Breakdowns in Consolidated Community Systems During Previous Year

Characteristic	Nation Number of Systems	Nation Percent of Systems
Number of Breakdowns During Previous Year		
0	2,000	48.0
1	300	6.8
2 - 5	1,000	28.2
6 - 10	200	5.2
11 - 20	200	5.8
21 - 50	100	3.3
51 - 75	5	0.1
More than 75	40	1.1
Could not be determined	60	1.6
Total	4,000	100.1
Reasons for Breakdowns		
Ruptured lines	1,600*	78.6*
Adjustment for pH level of water	600	31.6
Pump malfunction	600	29.3
Power failure	200	8.1
Flooding	200	8.1
Treatment equipment malfunction	10	0.4
Vandalism	10	0.3
Drought	2	0.1
Other reasons	80	3.6

*Numbers and percentages refer to the approximately 2,000 systems which had at least one breakdown. However, one system may have given several reasons for one breakdown, and thus may have been tallied separately for each of several reasons. As a result, the total number of systems in the table exceeds 2,000, and the total percent of systems exceeds 100.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

As to difficulties which interfered with the acquisition of water from the source, the NSA findings showed that about 500 consolidated community systems (about 12 percent of all consolidated systems) sometimes had such difficulties. Even though nearly 90 percent of the consolidated systems used purchased water as one source, many of the difficulties were associated with groundwater sources (Table VII-120). Also, contamination was the foremost problem among systems having difficulty obtaining groundwater, even though this was a relatively infrequent problem for independent community systems using groundwater (Table VII-99). On the other hand, the other common problems—equipment breakdowns, weather problems, and insufficient water quantity—were frequently cited both by independent community systems and by intermediate systems which reported difficulties obtaining source water.

Water test history at consolidated community systems

Water quality—in addition to supply availability—was an important indication of the success of the system operation in providing satisfactory service to customers. Thus, as was true for both intermediate and independent systems, information about both bacteriological and chemical testing was obtained. The results for bacteriological testing are presented here first, the results for chemical testing second.

— Bacteriological water quality tests

As seen in Table VII-121, bacteriological testing was done at nearly all consolidated community systems. This finding was consistent with NSA data pointing to increased incidence of testing at systems as they increased in size. Thus, the proportion of systems doing bacteriological testing rose from 22.4 percent of intermediate systems, to 91.2 percent of independent community systems, to nearly 100 percent of consolidated community systems.

Table VII-120

Difficulties in Obtaining Water for Consolidated Community Systems Using Groundwater, Purchased Water, and Surface Water

Difficulties	Nation	
	Number of Systems*	Percent of Systems*
Groundwater		
No difficulties	440	58.4
Contamination	290	38.1
Equipment breakdowns	20	2.4
Insufficient quantity	10	1.2
Weather problems	0	0.0
Loss of supply	0	0.0
Other difficulties	0	0.0
Purchased Water		
No difficulties	3,400	96.3
Equipment breakdowns	40	1.2
Water unavailable	10	0.3
Weather problems	5	0.1
Loss of supply	0	0.0
Contamination	0	0.0
Other difficulties	80	2.3
Surface Water		
No difficulties	290	95.5
Weather problems	10	3.5
Insufficient quantity	1	0.3
Loss of supply	0	0.0
Contamination	0	0.0
Equipment breakdowns	0	0.0
Other difficulties	2	0.6

*Number and percent of systems have as the base the total number of consolidated community systems using the respective sources: a total of 800 systems used groundwater; 300 used surface water; and 3,500 used purchased water (some systems used more than one source). However, one system might report more than one type of problem. Because of this potential for double counting, numerical and percentage totals are excluded.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VII-121

Consolidated Community Systems Performing Bacteriological Water Quality Tests, Frequency of Tests, and Organizations Conducting the Tests

Characteristic	Nation Number of Systems	Nation Percent of Systems
Testing Performed		
Bacteriological tests performed at some time	3,980	99.7
Bacteriological tests not performed at any time	10	0.3
Total	4,000	100.0
Frequency of Tests for Systems Performing Tests at Some Time		
At least once every three months	20	0.6
At least once every month	3,100	79.4
At least once every week	400	10.6
At least once every day	400	9.4
Total	3,980	100.0
Organizations Conducting Tests		
Public health department	1,500	37.0
State environmental department	1,300	31.7
System laboratory	500	11.4
System laboratory and either public health department or state environmental department	400	9.1
Private laboratory	300	8.5
Public health department and private laboratory	1	0.0
Other	100	2.3
Total	3,980	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

In addition, testing was done more frequently at consolidated community systems than at other multiple-connection systems serving rural America. Testing at monthly intervals—or more frequently—was done at about 15 percent of intermediate systems which tested, at about 85 percent of independent systems which tested, and at about 99 percent of consolidated systems which tested. The difference becomes even more striking when one recalls that about 73 percent of intermediate systems and about 8 percent of independent systems did not perform bacteriological tests at all. In contrast, nearly all consolidated systems performed the tests. It followed that nearly all consolidated systems did bacteriological tests at least once every month, a testing schedule which was consistent with federal drinking water regulation requirements, but which was not achieved by nearly as large a proportion of other multiple-connection systems. (The intermediate systems, of course, generally were not subject to the federal regulations.)

In terms of organizations conducting the tests, the majority of systems relied on outside testing sources, as did both intermediate and independent systems. On the other hand, the proportion of consolidated systems using their own laboratories exclusively (11.4 percent, as seen in Table VII-121), was larger than the relevant proportions of independent systems (1.9 percent) and intermediate systems (0 percent). This was consistent with other NSA data which indicated that the consolidated systems were more complex and perhaps more self-reliant than other systems. These characteristics presumably referred to the system as a whole, however, rather than to that particular segment which purchased water. This presumption could not be proved, nevertheless, since it was not possible in the NSA analysis to determine whether the data referred to the overall system or to a segment of the system (see earlier discussion in this chapter for explanation).

To assess the results of the bacteriological tests, inquiries were made in the NSA about the number of tests which showed that the quality of the water met the quality prescribed by relevant local, state, or federal regulations. The NSA analysis was limited to tests performed during the preceding year, and to a total of twelve tests. By dividing the total number of tests by the number which had passing results for each consolidated system (as was done for each intermediate and independent system), ratios were obtained which showed the percentage of tests passed. Since bacteriological tests were performed at nearly all consolidated systems, ratios were obtained for nearly all systems. Specifically, ratios were obtained for all 4,000 systems, except for about 70 which either did not test or did not know the test results.

At about 3,800 consolidated systems (96.1 percent of those performing tests), the results of all of the bacteriological tests met the prescribed levels. At nearly all the rest of the systems (3.4 percent), more than 90 percent of the tests had results which met the prescribed levels. Overall, the test-result record of consolidated systems was slightly better than that for intermediate and independent systems, particularly since nearly all consolidated systems did bacteriological testing.

— Chemical water quality tests

Although nearly all consolidated community systems tested for bacteriological water quality, about 15 percent (600 systems) did not test for chemical (or physical) water quality; about 3,200 did test. In addition, it was not known whether chemical testing was done at an additional 200 systems (5.5 percent). Thus, although a considerably larger proportion of consolidated than independent systems (80 percent compared to 54 percent) reported chemical testing, a substantial proportion of all community systems did not test water for chemical quality.

The data in Table VII-122 show that most consolidated community systems that tested had performed the tests for chemical water quality within a year of the NSA survey (a small number of system interviews were performed in 1979, but the bulk of the interviews were completed by the end of 1978). Specifically, about 81

Table VII-122

Year of Most Recent Test for Chemical and Physical Water Quality in Consolidated Community Systems

	Nation	
Year of Most Recent Test	Number of Systems	Percent of Systems
1974 or earlier	460	14.2
1975	1	0.0
1976	60	1.8
1977	1,400	42.9
1978	1,000	33.4
1979	160	4.9
Could not be determined	90	2.7
*Total	3,200	99.9

*Total of those systems performing tests.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

percent of systems tested from 1977 through 1979. Again, the record for consolidated systems was superior to that for independent systems in terms of currency of testing. As was true for the chemical-test results obtained at independent community systems, the results for consolidated systems were not assessed in the NSA because of variability in the year of the tests, in testing procedures, and in other conditions.

Water test history at households served by consolidated systems

Consolidated systems served 2.5 million rural households (11.3 percent of all rural households). Household water quality tests had been done at 5.4 percent of the households—a proportion nearly identical to that among households served by independent systems. Tests had not been performed at 89.3 percent of the consolidated-system households, and it was not known whether tests had been done at 5.3 percent.

In those consolidated-system households in which testing had been done, two or more tests had been performed in 21.8 percent, compared to 33.0 percent of independent-system households. In addition to having generally fewer tests, the consolidated-system households had a maximum of only six tests, compared to a maximum of more than 95 in households served by independent systems.

The testing in consolidated-system households was focused more in late spring than in summer as in the independent-system households. In 28.6 percent of the former households, the tests were done in April or May. In about 14 percent, tests were performed in January, June, or July. No tests were reported later in the year, but the month of testing was not known at nearly 58 percent of the households.

Testing at consolidated-system households generally was less current than either at independent-system households or at individual-system households. That is, the most recent test was before 1960 in 32.5 percent of consolidated-system households, but in only 1.2 percent of independent-system households and in only 8.7 percent of individual-system households. The last test was done during 1970-79 in 60.1 percent of households served by consolidated systems; the year of the test was not known in 7.4 percent of the households.

As was true for households served by independent systems, the most frequently cited reason for the test (in 59.0 percent of the households) was to determine if a system alteration were needed. Installation of a new system was the reason in about 23 percent of the households. In 4.8 percent of the households (6,000), however, the test was done because someone had become ill and the water was suspected. In comparison, this health-related reason was cited in 1.5 percent of the independent-system households (7,000) and in 2.6 percent of individual-system households (9,000). To complete the list of reasons given in consolidated-system households: the test was performed to check the water after some natural disaster in 3.7 percent of households, and the test was done for some unknown reason in 9.0 percent.

A household member usually had requested the test in consolidated-system households. This occurred in 63 percent of households in which testing was done, more than twice the comparable proportion of independent-system households and slightly larger than the comparable proportion of individual-system households. The test request came from either local or state officials in only 8.5 percent of the consolidated-system households, and the source of the request was not known in 9.0 percent of the households. In nearly 20 percent of the households, however, the test was done as a standard procedure of the system serving the household. This proportion was considerably larger than that for independent-system households (12.9 percent), and it was consistent with the somewhat more comprehensive operational program in the consolidated systems—as indicated by the extent of water quality testing in the system itself (see earlier section on "water test history at consolidated community systems"), by the operational staffing level, and by other features.

The testing was a combination of bacteriological and chemical analysis at only 9.5 percent of consolidated-system households, compared to about twice that percentage at independent-system households. Only bacteriological tests were done at about 20 percent of the consolidated-system households, and only chemical tests were done at about 46 percent of households—about three times the comparable percentage for independent-system households. The type of test was unknown at 25.1 percent of consolidated-system households.

As was true both for individual-system households and for independent-system households, the test results often were not known. This was the situation in about 62 percent of households in which bacteriological testing was done, and in about 72 percent of households in which chemical testing was done. At about 38 percent of households in which bacteriological testing was done, the results were acceptable (within the applicable standard). At no households were bacteriological results known not to be within the standard. At the households in which chemical testing was done, three of the seventeen constituents inquired about were found in concentrations which exceeded the applicable standards. The findings for these three constituents were in contrast to those in individual-system and independent-system households. That is, concentrations of iron exceeded the applicable standards in 15.8 percent of the relevant consolidated-system households (17,000), compared to only 2.6 percent of independent-system households (10,000) and only 5.5 percent of individual-system households (13,000). Fluoride and turbidity (the latter actually is a physical rather than a chemical measurement) each exceeded the standards in 6.7 percent of the consolidated-system households, but neither constituent was found in unacceptable concentrations in individual-system or independent-system households.

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VIII

Economics of Rural Water Systems

Rural water systems exist principally to secure a vital and occasionally scarce physical resource from a repository and allocate it to some conglomeration of residential users and commercial establishments. In the process of fulfilling this specialized but indispensable objective, these organizations incur a variety of costs or expenses. Some of these costs are related to capital expenditures for both original construction and replacement items, while others arise from operating and maintenance activity.

The costs of producing potable water reflect, in part, the quality and quantity of the source water. The poorer the quality of source water, the more expense involved in treating the water prior to delivery. Low quantity or intermittent producing sources often entail the development of several supplies in order to meet production requirements. System costs also reflect the engineering or technological features of the supply system; some technologies are more costly but more efficient than others, even at the same level of plant size. Mode of treatment used by the system also has differential cost effects. Another differential cost factor is labor to maintain and operate the plant. A profile of these components of costs was developed in Chapter VII. Having considered those components there, concern in this chapter is with the complementary information about actual costs entailed.

Although cost is a central economic indicator and a primary concern of this chapter, the NSA did not compile the comprehensive range of material necessary for a detailed cost summary. Instead, the NSA acquired information about the magnitude of selected costs and types of financing mechanisms. In particular, the data summarized in Chapter VIII are designed to address several general considerations such as the amount of funds expended for initial construction or on major alterations, the sources of those funds, interest rate levels, and the length of repayment periods. Findings have also been presented on the amount invested from a particular funding source as well as on the governmental levels and entities most involved in the support of rural water systems. Data on revenues, operating and maintenance costs, and debt retirement are presented last.

Data on these economic parameters were solicited for all multiple connection systems included in the NSA study. However, the data obtained from intermediate systems was less complete than for community systems. This incompleteness is, no doubt, in part a function of the informal manner in which intermediate systems are financed and operated. They tend to be not only small, but individually financed. Few have a regularized method of billing or generating revenue for water delivered. Moreover, the operation and maintenance of these systems tends to be irregular and ad hoc. By contrast, the data on these economic parameters was more complete and accurate for community systems.

Because of the more complete information about community financing, these findings have been presented first. These systems reveal the largest and most substantively typical patterns of economic activity. The economic patterns of intermediate systems have been presented second, and provided many interesting and stark contrasts to the profile of economic and financing patterns of community systems.

No attempt was made to obtain data on the construction, alteration, or operational costs for individual systems. Early attempts in the design of the NSA revealed that such an attempt was too difficult for the large majority of household residents who tended to own and operate their own supply. Hence no results have been presented in this chapter on the economics of individual water systems.

Another constraint on the present chapter which is in contrast to previous descriptive chapters that constitute this report is that the findings are compiled only at the national level. The usual subnational groupings that appeared in other chapters of the report are not used in this chapter, nor is the independent/consolidated dichotomy that was employed in the preceding chapter. Although these distinctions may be as important in this context as elsewhere, their utility is negated by the limited number of systems in many of the tabulations. Some subsets of systems are delineated here, but only according to some salient economic or financial characteristic. While this decision abbreviates the chapter somewhat, it also improves the comprehensibility of its contents.

As indicated in Chapter VII, the actual number of community systems investigated was 800, which projects to a representation of 34,000 systems after applying the sampling weight. Likewise, the actual number of intermediate systems was 294 which projects to 845,000 systems nationally.

COMMUNITY WATER SYSTEMS

The material presented for community systems is organized into several discrete sections. Since original construction and major alterations to the physical/engineering features of a supply system represent a large cost component to a system, information is compiled first on the costs of construction activity; this is followed by a general enumeration of the sources of financing utilized to pay these costs. Then, more specific data are provided on financing patterns and the various modes of financial support used by community systems. The emphasis in these latter sections is on public financing and agencies that are active in financing the construction of rural water systems as well as the amount of funds obtained from them. After this, material is presented on other forms of financing, including bonds that were issued and loans secured from commercial financial institutions. The segment on community systems concludes with data on revenues and other current components of cost—debt retirement and maintenance and operating costs.

CONSTRUCTION COSTS FOR COMMUNITY SYSTEMS

To develop some indication of the present cost configuration of community systems, the NSA acquired information on the amount of funds allocated to construction activity. This construction activity could have referred to the original installation of the system's physical facilities or it could have represented only the most recent major alteration. As explained in Chapter VII, for a small system, a major alteration could have consisted of a relatively simple improvement, such as replacing a malfunctioning pump or some other critical device, whereas for a larger system, a more elaborate effort, such as expanding distribution and processing facilities or building a reservoir or some other impoundment would constitute a major alteration. The NSA makes no distinction between these activities because, in each system's context, they all place a financial burden on the system that may be so substantial that it often can only be diminished by soliciting some form of financial assistance.

Since the cost data were compiled according to when the construction activity was completed, they were not directly comparable: because of inflation, real or actual costs could be the same even though the corresponding dollar amounts may be very different. To establish the necessary comparability, the cost data were converted into 1978 constant dollars by applying the appropriate adjustment factors. More generally, all dollar amounts in this chapter are standardized and expressed in 1978 dollars.

There are several possible schemes available for accomplishing this standardization of costs. Perhaps the most general scheme is to use a general price deflator based on an index such as the consumer price index. This scheme was rejected because its coverage is too broad, reflecting changes in personal consumption items like food, clothing, cars, and other "market basket" items, as well as less personal durable items. Such a scheme was not specific enough to accurately reflect changes in water construction costs. A second commonly used scheme for standardizing construction costs is the engineering construction cost index, updated recurringly in the Engineering News-Record.[1] However, this scheme was rejected because, though more specific to the data needs here, this index reflects all kinds of construction—highways, airports, hospitals, dams, residences, and so forth—which differ significantly, in many ways, from the construction requirements of water supply systems. To employ such an index may have also inadvertently introduced inaccuracies in the results compiled.

It was decided that the more accurate scheme for standardization to 1978 dollars was the implicit price deflators for the construction of water supply facilities, available in two statistical sources published by the Bureau of Economic Analysis.[2] The virtue of this scheme is that these deflators are specific to water supply construction, and therefore provide more realistic standardized values. A second virtue of this scheme is that the deflators are available back to 1929 which permitted the conversion of construction costs occurring prior to 1940.

Hence, the costs for the construction activity of water supply systems were standardized by using implicit price deflators for the initial construction or alteration of water supply facilities. The following equations were used in calculating the standardized cost:

(1) standardization index = f (Age of the System) and

(2) $$\text{standardized cost} = \frac{\text{cost of initial construction or alteration} \times 175.0}{\text{standardization index}}$$

where 175.0 is the standardization index for 1978 using 1972 as the base.

As would be expected given the vast dissimilarities in the community systems that provide water to rural households, the costs of construction activity varied appreciably. Table VIII-1 contains the cost information acquired from community water systems, excluding those systems that were continuously in the process of altering their facilities. The costs ranged from a minimum of $90 to a maximum of $35.0 million and the median cost was around $14,000. Since the distribution of construction costs included several very large values, the mean of $270,000 was substantially greater than the median. About 7.5 percent of the systems (2,492) expended less than $1,000, while approximately the same percentage (7.1 percent or 2,360) reported costs in excess of $500,000. Between these extreme categories, 13.6 percent of community systems (4,521) stipulated constructions costing more than $1,000 but less than or equal to $5,000, and 10.4 percent (3,462) had expenditures above $5,000 but less than $10,000. Cumulatively, 47.7 percent (15,848) of the systems in Table VIII-1 had costs of $50,000 or less, while 21.5 percent (7,129) reported construction expenses of more than $100,000. Somewhat significantly, around 8,330 systems (25.1 percent) could not or did not provide construction cost information. This may suggest that these systems do not have knowledge of their costs, do not maintain complete financial records, or refused to respond to the interviewer when asked this particular question. Unfortunately, this large percentage of missing data will affect the certainty of later estimates as it has the estimate of the true median and mean here.

GENERAL FINANCING SOURCES FOR COMMUNITY SYSTEMS

Community systems employ a variety of mechanisms to finance the costs of their construction activity. Generally, systems may finance these costs internally through reserve funds or some other collection of surplus assets, or they may rely upon some external source. External sources include loans and grants from both government agencies and private organizations, commercial loans, and

Table VIII-1

Construction Costs for Community Systems in Constant 1978 Dollars**

Cost in 1978 Dollars	Number of Systems	Percent of Systems
Less than $1,000	2,492	7.5
$1,001 - $5,000	4,521	13.6
$5,001 - $10,000	3,462	10.4
$10,001 - $15,000	2,159	6.5
$15,001 - $50,000	3,214	9.7
$50,001 - $100,000	1,910	5.7
$100,001 - $200,000	2,176	6.6
$200,001 - $500,000	2,593	7.8
More than $500,000	2,360	7.1
Unknown	8,330	25.1
*Total	33,217	100.0

Median:	$14,000
Mean:	$270,000
Minimum:	$90
Maximum:	$35.0 million

*Table excludes systems undergoing continuous alterations.

**Construction costs refer to costs incurred in initial construction or major alterations to the system, whichever is most recent.

bonds. Financial assistance may be secured from any of these sources, depending upon such factors as the system's credit status, the magnitude of the support requirement (construction and alteration costs), and the system's eligibility for certain government programs.

Not all systems qualify for assistance from each of these sources, which is the principal reason that some sources are used more prevalently than others. Another reason for the prominence of certain financing sources is that some sources present appreciable economic advantages to systems with the necessary qualifications. Many government loans, for example, provide a kind of indirect subsidy to the systems that secure them because the interest rates on government loans have been, historically, substantially lower than the levels established by commercial financial institutions. Government loans, however, are not typically available to privately-owned-for-profit systems or to systems that do not satisfy particular sets of conditions. These particular conditions differ according to the agency administering the loan program and only function to make it possible for the systems to compete for the funds. Actual funding decisions are based on a number of criteria, which may be why many systems do not receive loans even though they may conform to the prevailing eligibility standards.

Table VIII-2 reports data on the frequency with which internal and external sources of financing are employed by rural community water systems. Some 47.0 percent of the systems (11,936) indicated that their construction costs were financed by internal sources only, while 39.2 percent (9,941) used some external source only. An additional segment of these community systems (9.7 percent, or 2,463) obtained financing for a combination of internal and external sources, while the source of financing could not be determined for 4.1 percent (1,045). Though the proportion of systems using only internal sources to finance construction costs may seem high, it must be remembered that costs of major alterations have been included as a construction cost and, as will be presented later, the dollar amounts

Table VIII-2

Use of Internal and External Financing for Construction of Community Systems

Source of Financing	Number of Systems	Percent of Systems
Internal only	11,936	47.0
External only	9,941	39.2
Both	2,463	9.7
Could not be determined	1,045	4.1
*Total	25,385	100.0

*Table includes all community systems that could supply information on both construction costs and date of completion, as well as systems undergoing continuous alterations.

involved from internal source financing are small by comparison with external sources of funding.

Internal financing sources for community systems

To minimize or avoid short- and long-term debt, many community systems rely upon internal sources to finance their capital expenditures. These internal sources include reserve funds, retained earnings, and other forms of capital. Generally, the system has control over the allocation of funds from these sources, which is perhaps a secondary reason for their popularity. The primary advantages of expending internal funds are that they do not increase the system's debt load and are less expensive to administer. These are relatively important considerations, particularly for privately owned and smaller systems and those with limited financial resources. Since most community systems cannot encumber their operations with too much debt, internal capital provides an essential alternative to other modes of financing.

The amount of funds invested from internal sources is another indication of the extent to which community systems depend upon this means of financial support. Table VIII-3 provides this information for the approximately 14,400 systems that relied on internal sources exclusively or in combination with external funds to finance their construction activity. These amounts, which are expressed in Table VIII-3 in thousands of dollars, varied from a minimum of $90 to a maximum of $3.4 million. The median amount invested was about $6,000, while the mean was approximately $25,000. An examination of the categories in the table suggests that the largest percentages of systems invested between $3,000 and $4,000 (25.0 percent, or 3,600 systems) or from $5,000 to $10,000 (14.4 percent, or 2,076 systems). An additional 13.4 percent of the systems (1,924) expended from $11,000 to $15,000, and 9.6 percent (1,389) invested less than $1,000. Only 2.0 percent of the systems invested more than $200,000, and another 2.9 percent (412)

Table VIII-3

Amount Invested from Internal Sources (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 1	1,389	9.6
1 - 2	1,584	11.0
3 - 4	3,600	25.0
5 - 10	2,076	14.4
11 - 15	1,924	13.4
16 - 20	378	2.6
21 - 50	1,365	9.5
51 - 100	753	5.2
101 - 200	636	4.4
More than 200	282	2.0
Unknown	412	2.9
Total	14,399	100.0

Median:	$6,000
Mean:	$25,000
Minimum:	$90
Maximum:	$3.4 million

that employed internal sources did not know the amount. The magnitude of these amounts suggests that internal sources were used to support construction activities that were modest in scale or were precipitated by emergencies or other unanticipated developments.

External financing sources for community systems

Over 12,000 rural community water systems finance construction projects with funds acquired exclusively from external sources or in combination with internal sources. These external sources consist of grants and loans available from government agencies, bonds, and commercial loans. Government grants, of course, are the most advantageous from a financial standpoint because the systems that receive them do not increase their debt loads. Similarly, since government loans are usually secured at comparatively low interest rates, they also represent an inexpensive source of financing. Bonds provide systems with an effective mechanism for raising capital, but they may be issued only by systems that possess the required statutory authority. Loans from banks and other commercial establishments are also a pervasive source of capital, although they usually carry the highest interest rates.

Table VIII-4 presents information on the number and percent of community systems that reported acquiring financial support from each of these four external capital sources. The largest proportion of systems, 36.0 percent (4,470) obtained loans from government agencies, while another 30.3 percent (3,756) financed their construction activities with commercial loans. Grants from government agencies were another prominent source of construction capital, with 29.2 percent of the systems (3,618) designating that support mechanism, and 26.5 percent (3,289) used municipal bonds to produce funds for their capital improvements. These results indicate that loans, whether secured from government organizations or banks, are

Table VIII-4

External Sources of Financing for Construction of Community Systems

Source of Financing	Number of Systems	Percent of Systems
Government agency loans	4,470	36.0
Commercial loans	3,756	30.3
Government agency grants	3,618	29.2
Municipal bonds	3,289	26.5
*Total	12,404	

*Table includes 9,941 systems with only external sources of financing and 2,463 systems with both internal and external sources. Total of percentages exceeds 100 percent because some systems obtained funds from more than one external source.

the most prevalent mode of external financing, followed by government grants and municipal bonds.

Since all these financial sources have not always been available to a given system, the material in Table VIII-4 may not constitute an accurate reflection of more recent funding patterns. Therefore, the NSA compiled the information on external capital sources again—this time, for only those systems that financed some type of improvement between 1965 and 1978. The recompilation was limited to funding after 1965 because the main federal government agencies financing water supply construction—FmHA, HUD, EDA—did not regularly award grants to water systems before then, though loans could be obtained. The information, presented in Table VIII-5, suggests that since 1965, loans and grants are only slightly more prevalent than previously. (Compare with Table VIII-4, which included financing construction activity prior to 1965 as well as after), but municipal bonds are used by a somewhat smaller proportion of community systems. The percentage of community systems relying on loans, including those from government agencies and commercial establishments, increases from 66.3 percent when all construction activity is considered (Table VIII-4) to 69.3 percent when tabulated only for the 1965-78 period (Table VIII-5). Likewise, the proportion of systems that received government grants also increases, but only from 29.2 percent to 30.5 percent. Compensating for these increases is an approximately 5 point decline in the percentage of systems that issued municipal bonds to secure construction funds. The percent that depended upon municipal bonds was 26.5 for all construction activity reported by community systems (Table VIII-4), but only 21.8 percent in the 1965-78 period. Although this pronounced shift in support patterns could be attributed to many factors, it is most probably due to the increased involvement by all levels of government in the financing of rural water systems since 1965 and to changing ownership arrangements.

Table VIII-5

External Sources of Financing for Construction of Community Systems, 1965 - 1978

Source of Financing	Number of Systems	Percent of Systems
Government agency loans	4,197	37.7
Commercial loans	3,522	31.6
Government agency grants	3,399	30.5
Municipal bonds	2,423	21.8
*Total	11,134	

*Total of percentages exceeds 100 percent because some systems obtained funds from more than one external source.

Public financing sources for community systems

The preceding section of this chapter established the importance of government agencies and other public entities to the financing of water system capital improvements. Public support of water systems involves all levels of government, including federal, state, and regional organizations. Other public entities, such as local government and special purpose districts, also have the legal authority to disperse funds to water systems. In addition to these entities, community water systems were able to secure loans and grants from a potpourri of sources—drought relief programs, Indian Health Service, municipal water authorities, county commissions, and so forth. Because none of these entities was mentioned frequently, they were aggregated into a category labelled "other."

Table VIII-6 provides information on the number and percent of community systems receiving loans and grants according to the governmental level with which the administering agency is affiliated. As would be expected, units of the federal government tend to be the most active in supporting rural water systems, followed by other public entities. Federal agencies provided loans to 95.7 percent of the community systems (4,279) that relied upon that external source of financing and awarded grants to 69.1 percent of those systems (2,499). Similarly, 15.8 percent of the community systems (573) that reported grants received them from an organization in the other category, compared to 2.0 percent of the systems (88) that secured loans from that source. Regional agencies were also a prevalent funding source for systems that solicited grants, but were not mentioned in conjunction with lending sources. State-level units provided grants to 13.3 percent of the systems (484) reporting that source of public support, but less than 1 percent of these systems (25) acquired a loan from a state agency. Hence though federal agencies were a source for both grants and loans, regional and state level agencies mainly provide support in the form of grants.

Table VIII-6

Public Sources of Financing for Construction of Community Systems

Source of Financing	Number of Systems	Percent of Systems
Loans		
Federal	4,279	95.7
State	25	0.6
Other	88	2.0
Unknown	78	1.7
Total	4,470	100.0
Grants		
Federal	2,499	69.1
Regional	313	8.7
State	484	13.3
Other	573	15.8
Unknown	301	8.3
*Total	3,618	

*Total of percentages exceeds 100 percent because some systems obtained more than one grant.

At the federal level, the Farmers Home Administration (FmHA) and Economic Development Administration (EDA) are the most prominent sources of both loans and grants. As indicated in Table VIII-7, FmHA provided loans to 93.2 percent of the community systems (3,937) that received them from federal agencies and 50.7 percent of the systems (1,266) that were awarded grants. By comparison, 5.7 percent of the systems (242) with federal loans received them from EDA, while 29.4 percent of the systems (735) reporting grants were awarded them by this federal agency. The Department of Housing and Urban Development (HUD) is also a source of federal support to community systems, although it was not mentioned as often as FmHA and EDA. Only 1.4 percent of the systems (59) with federal loans received them from HUD, although 22.0 percent (549) of the systems that were awarded grants indicated that HUD was the source of the funds. The Department of Defense (DOD) also funds the capital projects of rural water systems, but it is not a major financial contributor. DOD's participation in water system funding was restricted to 0.2 percent of the community systems (5) that acquired grants from federal organizations.

— Government agency loans

As noted previously, loans are an integral component of the arrangements that rural water systems use to finance their construction activity. Loans provide systems with a mechanism for raising substantial amounts of capital, while simultaneously facilitating the efforts of public agencies to support these improvements. These public agencies provide loans in varying amounts, at different interest rates, and for a variety of time periods. Information on the amount of the loans, their interest rates, and their repayment periods is essential to establishing the comparative effects of loans on the debt loads of these systems. This material reflects the magnitude of the system's capital requirements and debt retirement costs, and indicates whether the debt from these sources is short-term or long-

Table VIII-7

Federal Sources of Financing for Construction of Community Systems

Source of Financing	Number of Systems	Percent of Systems
Loans		
FmHA	3,987	93.2
HUD	59	1.4
EDA	242	5.7
*Total	4,279	
Grants		
FmHA	1,266	50.7
HUD	549	22.0
EDA	735	29.4
DOD	5	0.2
*Total	2,499	

*Total of percentages exceeds 100 percent because some systems obtained funds from more than one federal agency.

term. In this section, these data are tabulated according to the specific federal agency from which the loan was obtained as well as for the entire complement of state agencies that issued loans.

Amount of loans. Table VIII-8 presents information on the size of the loans acquired from FmHA by rural water systems expressed in 1978 constant dollars. The maximum loan awarded by the agency was $4.9 million, compared to a minimum of around $7,000. At $175,000, the median loan from FmHA was moderately large, but the average size loan of $288,000 was still larger. The more detailed aspects of the distribution of loan amounts are reflected in the number of systems at various intervals. For example, 17.8 percent of the systems (709) received loans of less than $21,000, while 16.6 percent (662) secured loans of more than $500,000. The largest proportion of systems (28.1 percent, or 1,120) obtained loans of between $200,000 and $500,000, while FmHA provided loans of between $100,000 and $200,000 to another 20.6 percent (820) of these community systems. These results suggest that many of these recipients of FmHA loans had a considerable demand for capital.

Although it is intended to characterize systems that receive loans from FmHA, the preceding observation also applies to systems that obtained loans from HUD. Table VIII-9 reports the distribution of loan amounts for the comparatively few community systems that borrowed funds from that agency. (It may be more proper to see these as loan guarantees or assurances rather than a direct loan from HUD, which mainly provides funding through its grants programs.) At the extremes, the minimum loan amount was $10,000, and the maximum was $1.9 million. While the median loan size was around $280,000, the size of the average loan was approximately $609,000. Only 15.3 percent of the systems (9) acquired loans of less than $21,000, and 38.9 percent (23) received loans of between $200,000 and $500,000. A relatively large proportion of systems with HUD loans (23.7 percent, or 14) received funds in excess of $1,000,000. Even though the

Table VIII-8

Amount of Loans Received from FmHA
(Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	709	17.8
21 - 100	592	14.8
101 - 200	820	20.6
201 - 500	1,120	28.1
501 - 1,000	528	13.2
More than 1,000	134	3.4
Unknown	84	2.1
Total	3,987	100.0

Median:	$175,000
Mean:	$288,000
Minimum:	$7,000
Maximum:	$4.9 million

Table VIII-9

Amount of Loans Received from HUD (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	9	15.3
21 - 100	0	0.0
101 - 200	0	0.0
201 - 500	23	38.9
501 - 1,000	13	22.1
More than 1,000	14	23.7
Total	59	100.0

Median:	$280,000
Mean:	$609,000
Minimum:	$10,000
Maximum:	$1.9 million

discontinuous nature of these loan amounts seem unusual, they should not be interpreted too literally because of the small number of systems that are represented in the table.

Table VIII-10 presents similar information, but only for those community systems that obtained loans from EDA. The minimum loan administered by this agency was close to $15,000, while the maximum was $5.4 million. However, the median loan amount of $237,000 was very similar to the average loan of $228,000. Again, the largest proportion of the systems (47.1 percent, or 114) received loans of between $201,000 and $500,000, but only a few systems reported loan amounts greater than $500,000 (6.6 percent, or 16). A substantial percentage of systems with loans from EDA acquired amounts of between $21,000 and $100,000 (24.4 percent, or 59), and another 11.6 percent (28) obtained loans of less than $21,000. When considered across the three federal organizations that issued loans to rural water systems, this material generally suggests that the systems securing these funds had capital requirements that tended to be similar. However, this is not intended to ignore the finding that particular systems with federal loans had capital needs that were extremely large or very small.

While few systems secured loans from state agencies, the amounts reported by those that did are presented in Table VIII-11. The minimum loan was $32,000, while the maximum was around $149,000. Similarly, the median loan provided by state agencies was $110,000, while the average amount was $109,000. Once again, caution must be used in assessing these data, since so few systems were involved in the tabulation.

Interest rates. To develop a more comprehensive description of the financial configuration of rural water systems, the NSA collected data on the annual interest rates corresponding to loans from public entities. These interest rates provide an indication of the liabilities assumed by systems that are attributable to the acquisition of capital funds. They also suggest which of these

Table VIII-10

Amount of Loans Received from EDA (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	28	11.6
21 - 100	59	24.4
101 - 200	2	0.8
201 - 500	114	47.1
501 - 1,000	15	6.2
More than 1,000	1	0.4
Unknown	23	9.5
Total	242	100.0

Median:	$237,000
Mean:	$228,000
Minimum:	$15,000
Maximum:	$5.4 million

Table VIII-11

Amount of Loans Received from State Agencies
(Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	0	0.0
21 - 100	16	64.0
101 - 200	9	36.0
201 - 500	0	0.0
501 - 1,000	0	0.0
More than 1,000	0	0.0
Total	25	100.0

Median:	$110,000
Mean:	$109,000
Minimum:	$32,000
Maximum:	$149,000

public sources makes capital available at the least expense to the systems. The data on interest rates were compiled only for the three federal agencies from which rural community water systems received loans, since the interest rates on loans issued by state agencies were virtually constant.

Essentially the same problem faced earlier in describing results on the amount of loans secured by water supply systems to meet construction costs exists also in the presentation of interest rates being paid by these systems. Many banks and lending agencies have increased the annual interest rates on its loans, reflecting the rise in the cost of money in the US economy. Because many of the water supply systems investigated in the NSA completed the original construction of their system (or have made major alterations) several decades ago, presenting the interest rates on loans secured then would not be comparable with the interest rates on more recent loans without first standardizing the rates to a comparable basis. A second reason for standardization is that even though some federal agencies lending money for the construction of water supply facilities have not increased the interest rate over the years (notably FmHA), it is the case that the money market has driven up the rate other agencies and commercial firms charge. Since the NSA is interested in comparing interest rates across governmental agencies, commercial firms, and the bond market, this comparison would only be meaningful with standardized values.

To illustrate the problem of unstandardized rates, suppose one was interested in comparing how two different systems fared, where one system had secured a loan in 1966 from FmHA with an interest rate of 5 percent, while the other system received a loan guarantee from HUD in 1975 with an interest rate of 7 percent. How do they compare? Because of the fluctuating value of money, reflecting the changing nature of the economy, these two systems may have negotiated a very similar arrangement in terms of their debt obligation. Again, standardization would make this comparison more meaningful.

There are literally dozens of schemes for standardization of interest rates. Some of these schemes are more sensitive to short-term changes and therefore are more useful to short-term financing arrangements, especially in the private sector of the economy. Other schemes are more sensitive to long-term trends and historic cyclical interest rate fluctuations and, therefore, are judged more useful to financing in the public sector. In the area of water supply construction, long-term financing is the general practice. Moreover, as Table VIII-5 indicated, governmental agencies are by far the major source of funding—the number of grants and loans from governmental agencies account for 65.2 percent of all external sources used by water supply systems for construction.

Because of the historical importance of governmental agencies in this funding area, the long-term governmental bond yield seemed the most appropriate scheme to use. It offers several advantages. First, the values for these yields are available for each year of concern, including the year 1978, which was the year of the study. Second, it reflects the borrowing rate of the government, i.e., the rate the government must pay to borrow money, which changes with the rate of inflation and the real value of money. Therefore, the differences between the interest rate governmental agencies charge systems and the rate it must pay to borrow money will reflect the relative advantage which systems have in borrowing from government agencies compared to other sources.

An alternative scheme which would have been useful in standardizing the interest rates on municipal bonds is the municipal bond yield scheme. But these yields often have more than one value for the same year, depending upon the grade, which is determined by the credit rating of the issuing municipality. In addition, if this scheme would have been used for this source of money and, separately, the governmental bond yield scheme used for governmental agency financing, this would result in two sets of standardized values which were not directly comparable. Such an outcome would make the desired contrasts across all sources of money, mentioned earlier, difficult.

Facing this dilemma, the decision was to employ only one standardizing scheme and that was the long-term governmental bond yield. Of course, if another scheme had been employed, essentially the same relative comparisons and conclusions would have been drawn.

The standardization procedure involves dividing the actual interest rate negotiated in a certain year by the long-term government bond yield value in that same year and then multiplying that ratio by the government bond yield in 1978 so that the standardized interest rates reflect the rates various agencies would have charged if all loans were made in 1978.[3] The equation used was:

$$\text{Standardized Interest Rate (t)} = \frac{\text{Reported Interest Rate (t)}}{\text{Long-term Gov. Bond Yield (t)}} \times 7.89$$

where 7.89 was the long-term government bond yield for 1978.

Table VIII-12 reports the annual standardized interest rates on loans obtained by community water systems from FmHA. The median standardized rate was 6.0 percent, compared to a mean of 7.2 percent. Likewise, the minimum rate was only 4.0 percent, but the maximum standardized rate was 15.4 percent. The majority of systems (56.4 percent, or 2,246) received loans at a standardized rate of 6.5 percent or less, although 17.3 percent (689) reported a standardized rate of more than 8.5 percent.

Standardized interest rates for the HUD loans to community systems are compiled in Table VIII-13. The median and mean were both 6.5 percent, and the minimum rate of 5.3 percent was only slightly different from the maximum rate of 7.5 percent. Some 54.2 percent (32) of the community systems borrowed capital from HUD at a standardized rate of from 6.6 percent to 7.5 percent, and 33.9 percent (20) were issued loans at standardized rates of between 5.6 percent and 6.5

Table VIII-12

Annual Standardized Interest Rates on Loans Received from FmHA

Standardized Interest Rate	Number of Systems	Percent of Systems
Less than 5.6%	473	11.9
5.6% - 6.5%	1,773	44.5
6.6% - 7.5%	436	10.9
7.6% - 8.5%	358	9.0
More than 8.5%	689	17.3
Unknown	258	6.5
Total	3,987	100.1

Median:	6.0%
Mean:	7.2%
Minimum:	4.0%
Maximum:	15.4%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VIII-13

Annual Standardized Interest Rates on Loans Received from HUD

Standardized Interest Rate	Number of Systems	Percent of Systems
Less than 5.6%	7	11.9
5.6% - 6.5%	20	33.9
6.6% - 7.5%	32	54.2
7.6% - 8.5%	0	0.0
More than 8.5%	0	0.0
Total	59	100.0

Median:	6.5%
Mean:	6.5%
Minimum:	5.3%
Maximum:	7.5%

percent. Again, since so few systems are included in this table, these results should be viewed cautiously.

Information on the annual standardized interest rates reported by community systems with EDA loans is presented in Table VIII-14. The median standardized rate of 6.8 percent was slightly above the average rate of 6.4 percent. While the standardized rates varied, they still only ranged from a minimum of 5.0 percent to a maximum of 7.6 percent. The more detailed information on the intervals suggests that 54.1 percent (131) of the systems were issued loans from EDA at standardized rates of between 6.6 percent and 7.5 percent, and another 21.1 percent (51) borrowed funds at standardized rates of less than 5.6 percent. A comparison of these results for all three agencies indicates that the standardized interest rates on EDA and HUD loans tend to be similar to the annual rates on loans administered by FmHA.

Loan repayment periods. Loan repayment periods are another factor to consider when evaluating the sources of funds that community systems use to finance their capital expenditures. Information about the length of time that a system has to satisfy the terms of a loan indicates whether the debt obligation is short-term or long-term, and is necessary to characterize more thoroughly the financial condition of the systems that secure this form of financing. Generally, short-term debt involves repayment periods of from one through five years, while long-term debt includes repayment periods in excess of five years. Long-term borrowing, in particular, has been an effective means of financing water system construction or improvements because of the high initial capital investment and the long physical lives of the facilities being replaced or installed.

Table VIII-15 reports material on the repayment periods corresponding to the loans obtained from the three federal organizations (FmHA, HUD, and EDA) and the various unspecified state agencies. As suggested by the summary statistics

Table VIII-14

Annual Standardized Interest Rates on Loans Received from EDA

Standardized Interest Rate	Number of Systems	Percent of Systems
Less than 5.6%	51	21.1
5.6% - 6.5%	21	8.7
6.6% - 7.5%	131	54.1
7.6% - 8.5%	13	5.4
More than 8.5%	0	0.0
Unknown	26	10.7
Total	242	100.0

Median:	6.8%
Mean:	6.4%
Minimum:	5.0%
Maximum:	7.6%

Table VIII-15

Repayment Periods on Loans from Federal Sources and State Agencies

Repayment Period	Number of Systems	Percent of Systems
FmHA		
10 - 39 years	814	20.4
40 years	2,336	58.6
41 - 70 years	690	17.3
Unknown	147	3.7
Total	3,987	100.0
HUD		
15 - 30 years	23	39.0
31 - 35 years	22	37.3
36 - 40 years	14	23.7
Total	59	100.0
EDA		
20 years	17	7.0
30 years	13	5.4
40 years	165	68.2
Unknown	47	19.4
Total	242	100.0
State Agencies		
5 years	3	12.0
10 years	0	0.0
15 years	9	36.0
20 years	13	52.0
Total	25	100.0

FmHa		HUD	
Median:	40 yrs.	Median	33 yrs.
Mean:	39 yrs.	Mean:	28 yrs.
EDA		State Agencies	
Median	39 yrs.	Median	18 yrs.
Mean	38 yrs.	Mean	16 yrs.

at the bottom of the table and reflected in the various distributions, FmHA and EDA issued loans with the longest repayment periods, while the repayment periods for the loans from state agencies tended to be shortest. The median and mean repayment periods for FmHA loans were 40 years and 39 years, respectively, compared to median and means of 39 years and 38 years for EDA loans, 33 years and 28 years for HUD loans, and 18 years and 16 years for loans acquired from state agencies. Repayment periods of 40 years were very common for systems with FmHA loans, with 58.6 percent (2,336) being concentrated at that specific point. EDA loans were issued for 20, 30, or 40 year periods only, with the latter being the most prevalent. Fully 68.2 percent of the systems (165) with EDA loans reported a repayment period of 40 years, while 39.0 percent of the systems that received loans from HUD designated repayment periods of between 15 and 30 years. Apparently, state agencies were the only sources of short-term loans, since the repayment periods of the federal loans were always ten years or more.

Present value of annuities. In order to achieve a comparative perspective on how well water supply systems have fared in securing low cost loans for construction or capital improvements, it was necessary to develop a summary value which would reflect the overall relative cost encumbered by the system to obtain the loan. Thus far, only the components of this cost factor have been described—the standardized interest rate and the repayment period. Unfortunately, neither of these components, considered separately, accurately portrays the cost to the system. Only when the interest rate and length of time to retirement of the loan obligation are combined into an overall measure is the cost of the loan determinable. By forming an indicator which combines these two components, one has a comparable basis for assessing the relative debt costs, say, for example, for two different systems, one of which assumed a loan with 5 percent interest and a forty-year repayment period and a second system which assumed a loan with 6 percent interest and a thirty-year repayment period.

For this purpose, the following equations were used to calculate the annual repayments on a loan (annual debt service charge). Assuming A_o is the amount of the loan made, A^* is the annual debt service charge, r is the standardized interest rate, and n is the repayment period, then:

$$A_o = \frac{A^*}{1 + r} + \frac{A^*}{(1 + r)^2} + \dots + \frac{A^*}{(1 + r)^n}. \qquad (1)$$

Multiplying both sides by (1 + r), equation (1) can be written as:

$$A_o(1 + r) = A^* + \frac{A^*}{1 + r} + \dots + \frac{A^*}{(1 + r)^{n - 1}}. \qquad (2)$$

Subtracting (1) from (2) the resulting equation is:

$$A_o r = A^* - \frac{A^*}{(1 + r)^n}. \qquad (3)$$

Then simplifying (3) to highlight A^*, the annual debt service charge:

$$A^* = A_o r \left[\frac{1}{1 - \frac{1}{(1 + r)^n}} \right] \qquad (4)$$

If all these systems had acquired loans with exactly the same repayment period, say 40 years, but with varying interest rates, using equation (4) above, one can compare the relative cost burden or cost break assumed by the water supply systems for loans taken to cover construction or capital improvements to their plants. However, as already seen, this is not the case. Therefore, it was necessary to develop an overall index that could provide us with a measure for comparing the borrowing costs which also takes into account the variation in repayment periods.

Knowing that the cost of borrowing, relative to benefits received by the system, will vary by the interest rates and repayment periods, one strategy is to compute the present value of an annual debt obligation—i.e., the present value of annuities. Particularly, if the costs can be discounted, such investments in long term capital projects are attractive. This is the basic concept of present value of annuities.

The use of present values in this context is slightly different from the standard use in economics. Here it is simply being used to provide a relative comparison of borrowing capital costs, after discounting, which provides a summary indication of how well systems fare under a financial scheme in which society encourages the borrowing of money for water supply. The computations involved are used to bring fluctuations in past obligations up to the value in 1978.

Since A* is the annual debt service charge paid each year for n years, the total debt service charge, say A is:

$$A = (A^*)_{t=1} + (A^*)_{t=2} + \dots + (A^*)_{t=n}. \qquad (5)$$

These A* values are, however, not additive unless they are all expressed in terms of their value for a specific year, say, for $t = 0$. Such a transformation is accomplished by utilizing discount rates to standardize the annual debt service charge.

The discount rate reflects the society's rate of time preference for current consumption over future consumption. For example, a discount rate of value, R, means that one unit of current goods can be exchanged for (HR) units of goods delivered in the next period. The two major reasons for placing a lower weight on future benefits and costs are based on these assumptions: (a) the per capita consumption will rise over time and (b) the marginal social significance, or marginal utility, of consumption decreases with each rise in consumption.

For the purposes of our analysis, we have chosen a discount rate of 6.1 percent. This was the rate used by the federal government in 1978 for evaluating drinking water supply projects.[4]

It is not within the scope of this study to go into the details of analyzing whether 6.1 percent is an appropriate social discount rate, but we would like to point out that if a lower discount rate, say 4.0 percent, were selected, there would be a number of systems crossing from the lower categories, say \$91 through \$100, to higher classes, say \$101 through \$110. Similarly, a number of systems would change categories if a higher discount rate, say 7.9 percent, were chosen, but in an opposite direction. As a result, the present value table presented here is a useful tool for comparing relative cost-breaks obtained from each agency by rural water systems, but not for assessing the absolute amount of cost-breaks acquired.

Hence the process of computing present values under this scheme was as follows. If $(A^*)_{t=2}$ is to be expressed in terms of its value at t = 0, the new

$$A^* = \frac{(A^*)_{t=2}}{(1+R)^2} \qquad (6)$$

Since the new A* is expressed in terms of its value at t = 0, i.e., the present year, it is called the present value. Once the present values of all A*s are computed, they can be added to find the total present value, PV, where, R is the discount rate.

$$PV = \frac{A^*}{1+R} + \frac{A^*}{(1+R)^2} + \ldots + \frac{A^*}{(1+R)^n} \qquad (7)$$

On simplification,

$$PV = \frac{A^*}{R}\left[1 - \frac{1}{(1+R)^n}\right] \qquad (8)$$

Substituting A* from (4)

$$PV = A_o \frac{r}{R}\left[1 - \frac{1}{(1+R)^n}\right] \left[1 - \frac{1}{(1+r)^n}\right] \qquad (9)$$

To illustrate the utility of this equation for comparisons among loans, one can calculate the present values for each $100 unit of a loan, as has been done and presented next.

Besides being intrinsically important, interest rates and repayment periods are manifested in any cost break that may be available from these public funding sources. An indication of the magnitude of this break in the cost of borrowing is reflected in Table VIII-16, which contains information on the present value of annuities for each $100 in loans at a 6.1 percent discount rate. Basically, this material reflects the cost to the system for every $100 increment of loan funds obtained from FmHA, HUD, and EDA. Systems with present values below $100 are receiving a definite cost advantage while those with present values above $100 are not subsidized by the agencies issuing the loans. For example, a system with a present value of $80 is paying that amount for every $100 in loan funds, while a system with a present value of $110 is paying that much for the same amount of capital. The first system is receiving a 20 percent subsidy, since its capital costs are only 80 percent of the value of the loan, but the second system is paying 10 percent more than the loan's amount. The lower cost of borrowing from governmental agencies, compared to commercial agencies, is instrumental in maintaining the costs of producing and distributing water at artificially low levels.

The information reported in Table VIII-16 suggests that FmHA is more heavily involved than the other two organizations in subsidizing rural water systems. About 49 percent of the systems (1,955) had a present value of annuities less than or equal to $100, compared to 33.9 percent of the systems (20) with HUD administered loans, and only 21.1 percent of the systems (51) with loans secured from EDA. Some of the FmHA supported systems received subsidies of as much as 29 percent, while systems that borrowed money from EDA and HUD received a maximum subsidy of less than 20 percent. Over 35 percent of the systems with loans through FmHA had present values between $91 and $100 (37.9 percent, or

Table VIII-16

Present Value of Annuities on Loans Received from Federal Sources

Present Value of Annuities for $100 in Loans at 6.1% Discount Rate	Number of Systems	Percent of Systems
FmHA		
$71 - $80	55	1.4
$81 - $90	388	9.7
$91 - $95	701	17.6
$96 - $100	811	20.3
$101 - $110	466	11.7
$111 - $120	507	12.7
$121 - $150	105	2.6
$151 - $200	677	17.0
Unknown	277	6.9
Total	3,987	99.9
HUD		
$81 - $90	7	11.9
$91 - $100	13	22.0
$101 - $105	16	27.1
$106 - $110	23	39.0
Total	59	100.0
EDA		
$81 - $90	51	21.1
$91 - $100	0	0.0
$101 - $110	131	54.1
$111 - $120	13	5.4
Unknown	47	19.4
Total	242	100.0

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

1,512), which was a substantially higher percentage than the 22.0 percent of the systems (13) with HUD loans, and none of the systems that secured EDA loans had present values in that interval. Although FmHA provided more low cost loans to rural water systems, more systems with loans from this agency were also paying exorbitant capital costs when the loan repayment amounts are expressed in present value terms. Some systems (2.6 percent, or 105) with FmHA loans were paying from $21 to $50 more than the amount of the loan, while a somewhat substantial proportion (17.0 percent, or 677) were paying from $51 to $100 more than the loan amount. These systems may have had an unusually high level of annual debt retirement costs if they had capital requirements in addition to those that were presumably fulfilled by the funds provided by FmHA.

— Government agency grants

Grants represent another vital mechanism by which systems secure capital to finance construction projects. As indicated in Table VIII-4, grants from government agencies and organizations was the third most prominent source of external funds, as reflected in the number and percent of community systems that secured them. In that category of sources of financing (see Table VIII-6), the federal government was the major source of grants, followed by public entities that were not considered units of federal, regional, or state political structures. Various state and regional agencies also have the statutory authority to issue grants to community water systems. As another device for assessing the federal government's support of water systems, the NSA compiled information on the grant amounts from each of the three federal organizations (FmHA, HUD, and EDA), as well as relevant aggregations of grant amounts from regional, state, and other agencies. Again, the amounts in the following tabulations are expressed in 1978 constant dollars.

Table VIII-17 reports the grant amounts for the community systems that received such funds from FmHA. Generally, the amounts were relatively small, as was reflected in the median of $105,000 and the mean of $231,000. At the extremes, the grant amounts ranged from a minimum of $18,000 to a maximum of $1.1 million. Fully 33.0 percent of the systems (418) were awarded grants of less than $51,000, while 20.0 percent (253) received grants of between $101,000 and $200,000. About 30 percent of the systems (30.5 percent, or 387) secured grants in amounts varying from $201,000 to $1 million. An extremely small percentage obtained grants of more than $1 million (0.7 percent, or 9).

Grants from HUD, by comparison, appeared to be about the same size on the average, although there were some critical differences in the distribution of amounts. Table VIII-18, which contains the material on the amounts of grants awarded by HUD, suggests that the median grant amount was $164,000, and the average grant was $218,000. The grants from HUD had a large range, as was indicated by the minimum of $3,000 and the maximum of $2.9 million. Around 30 percent of the systems (30.2 percent, or 166) which received a grant from HUD for initial construction or major alteration, acquired grants of $201,000 to $500,000, while another 20.9 percent (115) solicited grants in amounts that varied from $51,000 to $100,000. Although a very small percentage of the systems (1.1 percent, or 6) reported grants in excess of $1 million , a greater proportion (11.8 percent, or 65) had grants of less than $21,000. The grant amounts could not be determined for 8.0 percent of the systems (44) that received financial assistance from HUD.

Table VIII-19 presents the amounts of grants that were awarded to community water systems from EDA. The median grant amount was $159,000, and the mean was $294,000. Consistent with the magnitude of the difference between the median and mean, the amounts varied from a minimum of $21,000 to a maximum of $3.2 million. Around 22 percent of the systems with EDA grants (22.2

Table VIII-17

Amount of Grants Received from FmHA (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	14	1.1
21 - 50	404	31.9
51 - 100	150	11.8
101 - 200	253	20.0
201 - 500	208	16.4
501 - 1,000	179	14.1
More than 1,000	9	0.7
Unknown	49	3.9
Total	1,266	99.9

Median:	$105,000
Mean:	$231,000
Minimum:	$18,000
Maximum:	$1.1 million

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VIII-18

Amount of Grants Received from HUD (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	65	11.8
21 - 50	8	1.5
51 - 100	115	20.9
101 - 200	90	16.4
201 - 500	166	30.2
501 - 1,000	55	10.0
More than 1,000	6	1.1
Unknown	44	8.0
Total	549	99.9

Median:	$164,000
Mean:	$218,000
Minimum:	$3,000
Maximum:	$2.9 million

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VIII-19

Amount of Grants Received from EDA
(Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	0	0.0
21 - 50	112	15.2
51 - 100	115	15.6
101 - 200	127	17.3
201 - 500	152	20.7
501 - 1,000	163	22.2
More than 1,000	21	2.9
Unknown	45	6.1
Total	735	100.0

Median:	$159,000
Mean:	$294,000
Minimum	$21,000
Maximum:	$3.2 million

percent, or 163) reported amounts ranging from $501,000 to $1 million, and another 20.7 percent (152) were awarded EDA grants of between $201,000 and $500,000. On the other hand, 30.8 percent of these systems received a grant between $21,000 and $100,000. Unlike the results for the other federal agencies, there were no systems with grants of less than $21,000, but again only a small proportion of systems (2.9 percent, or 21) obtained grants from EDA that exceeded $1 million.

The dollar amounts of grants received by community water systems from regional agencies are provided in Table VIII-20. According to this information, the median grant was $172,000, while the mean amount was $170,000. The range of amounts was substantially smaller than the extremes of the previous tabulations on grant amounts, as was reflected by the minimum of $16,000 and the maximum of $761,000. Generally, the grants from regional agencies tended to be either moderately large or relatively small, although a few systems (0.6 percent, or 2) had grants over $500,000 and several others (4.2 percent, or 13) were awarded grants of less than $21,000. The majority of systems (68.1 percent, or 213), however, reported grant amounts of between $101,000 and $500,000, while another large proportion (23.9 percent, or 75) stipulated grant amounts of $21,000 through $50,000.

Grants from state agencies also varied, as suggested by the contents of Table VIII-21. The median amount was $61,000, compared to a mean of $115,000. Beyond these central points in the distribution, the grant amounts ranged from a minimum of $3,000 to a maximum of $1.7 million. A considerable percentage of community systems (39.1 percent, or 189) with grants from state agencies reported amounts of between $51,000 and $100,000, and another 22.7 percent (110) received grants of less than $21,000. Cumulatively, around 94 percent of the systems (94.2 percent, or 456) with state agency grants indicated amounts below $201,000.

Somewhat unexpectedly, the dollar amounts of grants awarded by other government agencies were the largest of the sources considered by the NSA. Table

Table VIII-20

Amount of Grants Received from Regional Agencies (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	13	4.2
21 - 50	75	23.9
51 - 100	10	3.2
101 - 200	102	32.6
201 - 500	111	35.5
501 - 1,000	2	0.6
More than 1,000	0	0.0
Total	313	100.0

Median:	$172,000
Mean:	$170,000
Minimum:	$16,000
Maximum:	$761,000

Table VIII-21

Amount of Grants Received from State Agencies (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	110	22.7
21 - 50	87	18.0
51 - 100	189	39.1
101 - 200	70	14.4
201 - 500	14	2.9
501 - 1,000	3	0.6
More than 1,000	11	2.3
Total	484	100.0

Median:	$61,000
Mean:	$115,000
Minimum:	$3,000
Maximum:	$1.7 million

VIII-22 presents the grant amounts obtained from these agencies, again expressed in constant 1978 dollars. The median amount was $667,000, while the mean or average was $939,000. In contrast, the extreme amounts reported by community systems varied from a low of $5,000 to a high of $2.0 million. Only 10.0 percent of the systems (57) securing grants from the agencies received grants of less than $201,000, and 86.0 percent (493) indicated grant amounts between $201,000 and the $2.0 million maximum. Within this upper range, 38.0 percent of the systems (218) with grants from other agencies signified amounts in excess of $1.0 million, while another 35.3 percent (202) were issued grant funds of between $201,000 and $500,000. Given the magnitude of these amounts, grants from other agencies are probably solicited by systems with a significant demand for capital.

Private financing sources for community systems

All water systems, but particularly those that are not eligible for public assistance, occasionally have to raise capital by some alternative means. Publicly owned systems often resort to tax-exempt municipal bonds, while private systems frequently borrow funds from banks and other financial institutions. Both bonds and commercial loans provide an important mechanism for securing funds to those systems that cannot produce the capital internally or are unable to obtain it from governmental sources. To assess the role of commercial and financial agencies in supporting rural water systems, the NSA compiled some detailed information on bonds and grants. For bonds, this consisted of data on the amount of funds generated by issuing bonds, their coupon rates and maturity periods, and the present value of bond payments. The material on loans included tabulations on loan amounts and interest rates.

Table VIII-22

Amount of Grants Received from Other Agencies (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 21	21	3.7
21 - 50	0	0.0
51 - 100	0	0.0
101 - 200	36	6.3
201 - 500	202	35.3
501 - 1,000	73	12.7
More than 1,000	218	38.0
Unknown	23	4.0
Total	573	100.0

Median:	$667,000
Mean:	$939,000
Minimum:	$5,000
Maximum:	$2.0 million

— Municipal bonds

Traditionally, bonds have provided municipalities and other public entities with a suitable method for generating funds to support capital projects. Water systems may have their own authority to issue bonds or they may have to rely upon a municipality to place the bond on the market if the system is not fiscally independent. This legal status may be a factor in the system's credit rating, which affects the bond's coupon rate and maturity period. The coupon rate is the interest paid periodically to the bondholder and reflects the return that accrues to the bond-holders. Similarly, the maturity period indicates the length of time that the system will continue to have to pay for the funds produced by issuing the bond.

Table VIII-23 presents information on the amount of funds raised by issuing municipal bonds. The median face value of the bonds was $212,000, and the mean was $912,000. Compared to other sources of capital, bonds had the largest range, as was reflected by the minimum of $3,000 and the maximum of $35.0 million. Regarding the more detailed aspects of the distribution of bond amounts, 44.2 percent of the systems (1,456) issued bonds of $200,000 or less, while another 33.6 percent (1,106) reported bond amounts of between $201,000 and $1.0 million. A relatively large proportion of community systems (11.1 percent, or 363) issued bonds of face value between $1.0 million and $10.0 million and a small proportion (0.8 percent, or 25) even had bonds in excess of $10.0 million. Presumably, those with large bonds are metropolitan and urban systems that have service populations partially consisting of rural households, or else they are large rural water districts. Independent of which systems are included in this last category, they have extremely large capital requirements relative to systems that secured funding from other sources.

The coupon rate at which the bonds were issued is a major factor in determining how much they will cost the systems annually. Material on standardized coupon rates is reported in Table VIII-24. The median standardized rate was

Table VIII-23

Amount of Funds Raised by Issuing Municipal Bonds (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 51	211	6.4
51 - 100	628	19.1
101 - 150	458	13.9
151 - 200	159	4.8
201 - 300	349	10.6
301 - 400	244	7.4
401 - 500	187	5.7
501 - 1,000	326	9.9
1,001 - 5,000	315	9.6
5,001 - 10,000	48	1.5
More than 10,000	25	0.8
Unknown	339	10.3
Total	3,289	100.0

Median Face Value:	$212,000
Mean Face Value:	$912,000
Minimum:	$3,000
Maximum:	$35.0 million

Table VIII-24
Standardized Coupon Rates on Municipal Bonds

Standardized Coupon Rate	Number of Systems	Percent of Systems
3.6% - 4.5%	48	1.5
4.6% - 5.5%	167	5.1
5.6% - 6.5%	729	22.2
6.6% - 7.5%	449	13.7
7.6% - 8.5%	402	12.2
8.6% - 9.5%	209	6.4
9.6% - 10.5%	118	3.6
10.6% - 11.5%	103	3.1
More than 11.5%	60	1.8
Unknown	1,004	30.5
Total	3,289	100.1

Median:	6.9%
Mean:	7.4%
Minimum:	3.6%
Maximum:	20.6%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

6.9 percent, while the mean rate was 7.4 percent. Similarly, the standardized rates ranged from a minimum of 3.6 percent to a maximum of 20.6 percent. Since the rates were dispersed, there was less of a tendency for systems to be concentrated in particular intervals. For example, 22.2 percent of the systems (729) reported coupon rates of 5.6 percent through 6.5 percent, while another 13.7 percent (449) paid rates of 6.6 percent through 7.5 percent. Considering the lower and upper ends of this distribution, 1.5 percent of the systems (48) stipulated standardized rates between 3.6 percent and 4.5 percent, and 1.8 percent (60) specified rates in excess of 11.5 percent. The standardized rates could not be ascertained for 30.5 percent (1,004) of the systems that issued municipal bonds.

The maturity periods for the bonds, which are presented in Table VIII-25, suggest that the corresponding debt obligation is long-term rather than short-term. This is summarized by the median period, which was 20 years, and the mean, which was 22 years. The extremes, however, did range from a minimum of three years to a maximum of 50 years. Substantial proportions of systems reported maturity periods of 20 through 29 years (39.2 percent, or 1,288), 10 through 19 years (15.6 percent, or 517), and 30 through 39 years (14.2 percent, or 466). Comparatively small percentages of systems designated maturity periods of more than 39 years (3.6 percent, or 117) or less than 10 years (3.6 percent, or 117). Maturity periods could not be compiled for 23.8 percent (784) of the systems that used this source of financing.

When issued with the proper coupon rate and maturity period, bonds may also provide an attractive cost break to the systems that sell them. The subsidy is provided by the bond-holder, whose return from the bond is less than the present value of the bond's face value. To assess the extent to which community systems are subsidized by bonds, the NSA computed the present value of payments for each bond of $1,000 face value at a 6.1 percent discount rate. The interpretation of this information is the same as for the present value of loan repayments, except that

Table VIII-25
Maturity Period of Municipal Bonds

Maturity Period in Number of Years	Number of Systems	Percent of Systems
Less than 10	117	3.6
10 - 19	517	15.6
20 - 29	1,288	39.2
30 - 39	466	14.2
More than 39	117	3.6
Unknown	784	23.8
Total	3,289	100.0

Median:	20 years
Mean:	22 years
Minimum:	3 years
Maximum:	50 years

the reference value is now \$1,000 instead of \$100. Systems that are paying less than \$1,000 are receiving a subsidy, while in present value terms those with payments of \$1,000 or more are not being subsidized.

The method used for calculating the borrowing cost of capital by issuing municipal bonds is similar to the one used for the case of government agency loans discussed earlier except for the two modifications employed: (a) the annuity cost is replaced by the interest cost which is the annual interest on the face value of the bond, and (b) an additional term, $B/(1 + r)^n$, is introduced for the present value calculations, where B is the face value of the bond, r, the discount rate and n, the maturity period.

It should be noted that the borrowing cost presented here does not include the marketing costs incurred in preparing bonds for market and their actual delivery to the initial investment firms. According to a survey conducted by the Municipal Finance Officers Association, such marketing costs amounted to 5.5 percent of the value of bonds marketed in some instances.[5] But in our data base, we do not have information about these costs.

Furthermore, it should be noted that the present value method adopted here is for the cost calculations from the point of view of the bond issuers. This should not be confused with the perspective of the investor, individual or institutional, who buys these bonds in the capital market. Such an investor will be facing fluctuating prices, where the bond price is analogous to the present value in our calculations. As a result, the holding-period yield he gets will be subjected to change depending on the market price for the security at the beginning and the end of that period. This yield rate is similar to the discount rate in our calculations which is assumed to be constant to the date of final maturity. It has been possible to standardize and compare capital costs in this study because interest is restricted to the point of view of the rural community systems, the bond issuers.

The data on present values of payments for bonds are provided in Table VIII-26. As the information at the bottom of the table suggests, the median present value was $1,100 and the mean was $1,200. The present value of payments ranged from a minimum of $600 to a maximum of $3,100 per $1,000 face value. About 20 percent of the systems (20.4 percent, or 671) were able to arrange very favorable financing through bonds, as was indicated by the systems with payments of $999 or less. About 46 percent of the systems (45.8 percent, or 1,504) received no cost breaks, which is signified by those systems with payments of $1,000 or more. A small percentage of the systems (5.3 percent, or 174) were making payments that exceeded the present value by 50 percent or more. Unless this indebtedness were compensated for by subsidies from other sources, it could impose a severe burden on the financial resources of these systems.

— Commercial loans

Loans from commercial establishments represent another source of capital to systems that are engaged in any type of construction activity. Funds borrowed from banks can generally be secured more rapidly than from other sources, although they also tend to cost more. Commercial loans are most commonly used by privately owned systems that are not eligible for other forms of support. Since many community systems are privately-owned, this source of capital makes an important contribution to the economic viability of the entire complex of organizations that produce and distribute water. The information compiled in the NSA, which consisted of data on the amounts of these commercial loans and their interest rates, is essential to determining the magnitude of that contribution. Through oversight, information on repayment periods of commercial loans was not collected.

Table VIII-27 presents material on the amount of loans obtained from financial institutions by community systems. The median amount was only $18,000

Table VIII-26

Present Value of Payments for Municipal Bonds (Constant 1978 Dollars)

Present Value for $1,000 Face Value Bond at 6.1% Discount Rate	Number of Systems	Percent of Systems
Less than $900	135	4.1
$900 - $949	178	5.4
$950 - $999	358	10.9
$1,000 - $1,049	209	6.4
$1,050 - $1,099	181	5.5
$1,100 - $1,149	303	9.2
$1,150 - $1,199	154	4.7
$1,200 - $1,249	68	2.1
$1,250 - $1,299	134	4.1
$1,300 - $1,500	281	8.5
More than $1,500	174	5.3
Unknown	1,114	33.9
Total	3,289	100.1

Median:	$1,100
Mean:	$1,200
Minimum:	$600
Maximum:	$3,100

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VIII-27

Amount of Loans Obtained from Financial Institutions (Constant 1978 Dollars)

Amount in Thousands of 1978 Dollars	Number of Systems	Percent of Systems
Less than 6	655	17.4
6 - 10	263	7.0
11 - 15	663	17.7
16 - 20	596	15.9
21 - 30	121	3.2
31 - 40	539	14.4
41 - 50	53	1.4
51 - 100	328	8.7
More than 100	306	8.1
Unknown	232	6.2
Total	3,756	100.0

Median:	$18,000
Mean:	$76,000
Minimum:	$250
Maximum:	$16.4 million

and the mean was $76,000. Although this signified that the loans tended to be for relatively small amounts of funds, the variation was still substantial. The minimum amount was $250, compared to the maximum of $16.4 million. About 18 percent of the systems (17.7 percent, or 663) borrowed funds of $11,000 through $15,000, while another 17.4 percent (655) secured loans of less than $6,000. Only 8.1 percent (306) reported loan amounts of more than $100,000, and 8.7 percent (328) had commercial loans of between $51,000 and $100,000. Cumulatively, 58.0 percent of these community systems (2,177) acquired loans of $20,000 or less, and 77.0 percent (2,890) indicated amounts of $50,000 or less.

Information on the annual standardized interest rates on commercial loans is presented in Table VIII-28. While the median rate was 10.2 percent, the mean was 9.8 percent. The standardized rates ranged from a low of 0.0 percent to a high of 18.7 percent. Around 23 percent of the systems (22.8 percent, or 857) paid a standardized rate of 9.6 percent through 10.5 percent, and approximately the same proportion (21.9 percent, or 823) received loans with interest rates of 10.6 percent through 11.5 percent. At the extremes, 4.2 percent of the systems (159) were charged rates of less than 6.6 percent, while 4.0 percent reported rates of more than 11.5 percent. Again, the standardized rates could not be established for 23.2 percent of the systems (872) that secured loans from financial institutions.

Finding a commercial loan with no interest rate was surprising and therefore needs further explanation. The explanation is that the case involved a private endowment made available to individuals or firms in the local community for community projects. Those borrowing from the endowment were required to repay the principal amount borrowed, but no interest was charged. Since the loan did not involve any federal agencies, bonding markets, or other institutions discussed previously, the source was defined as most similar to a commercial loan.

Table VIII-28

Annual Standardized Interest Rates on Loans Received from Financial Institutions

Standardized Interest Rate	Number of Systems	Percent of Systems
Less than 6.6%	159	4.2
6.6% - 7.5%	35	0.9
7.6% - 8.5%	199	5.3
8.6% - 9.5%	662	17.6
9.6% - 10.5%	857	22.8
10.6% - 11.5%	823	21.9
More than 11.5%	149	4.0
Unknown	872	23.2
Total	3,756	99.9

Median:	10.2%
Mean:	9.8%
Minimum:	0.0%
Maximum:	18.7%

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

COMMUNITY SYSTEM REVENUES

The NSA collected data on revenues to augment the information on costs and financing arrangements. Generally, revenues referred to funds obtained from water operations only, but could have included joint water and sewer charges, or tax income. Even though these could be reflected in the tabulation of annual revenue, the intent of this section is to determine the amount of annual water-related revenue exclusive of other sources. Some systems, however, could not provide this information separately or simply misunderstood the question.

Annual revenues for community water systems are presented in Table VIII-29. The median revenue was $6,000, compared to the mean, which was $163,000. As would be expected, given the varying sizes of the systems in the table, the revenues ranged from a minimum of $400 to a maximum of $12.0 million. About 24 percent of the systems (23.9 percent, or 8,118) reported revenues of between $1,000 and $5,000; 14.9 percent (5,091) had revenues of $6,000 through $20,000; and 12.9 percent (4,386) collected annual revenues of between $21,000 and $50,000. A relatively small proportion (2.2 percent, or 738) had revenues of more than $1.0 million, while only 0.5 percent received revenues of less than $1,000. An appreciable percentage of the systems did not charge for water (17.7 percent, or 6,019) and the annual revenue could not be compiled for another 15.3 percent (5,188).

To counteract the effect of size, the NSA standardized each revenue amount by the system's number of service connections. The result of this computation, which is expressed in terms of dollars of revenue per connection, is reported in Table VIII-30. While the median was $70 per connection, the mean was $3,600. The annual revenues per connection varied from a low of $2 to a high of $245,000. Presumably, a system with such an extremely large amount either had a significant amount of retail water sales, conveyed a substantial volume of water to large-scale users, or the system's revenue figure included income that was

Table VIII-29
Annual Revenues for Community Systems

Amount in Thousands	Number of Systems	Percent of Systems
Less than 1	165	0.5
1 - 5	8,118	23.9
6 - 10	1,486	4.3
11 - 20	3,605	10.6
21 - 50	4,386	12.9
51 - 100	2,446	7.2
101 - 500	1,712	5.0
501 - 1,000	151	0.4
More than 1,000	738	2.2
No charge for water	6,019	17.7
Unknown	5,188	15.3
Total	34,014	100.0

Median:	$6,000
Mean:	$163,000
Minimum:	$400
Maximum:	$12.0 million

Table VIII-30
Annual Revenues per Connection

Dollars per Connection	Number of Systems	Percent of Systems
Less than 5	166	0.5
5 - 15	149	0.4
15 - 25	516	1.5
26 - 50	3,814	11.2
51 - 100	9,229	27.1
101 - 500	7,208	21.2
501 - 1,000	1,041	3.1
More than 1,000	684	2.0
No charge for water	6,019	17.7
Unknown	5,188	15.3
Total	34,014	100.0

Median: $70
Mean: $3,600
Minimum: $2
Maximum: $245,000

unrelated to water production. Approximately 27 percent (27.1 percent, or 9,229) had per connection revenues of $51 through $100, and 21.2 percent (7,208) were in the interval of $101 through $500. About 14 percent of community systems (13.6 percent, or 4,645) had revenues from less than $51, while another 5.1 percent (1,725) collected revenues of more than $500 annually from each connection. Once again, per connection revenues could not be tabulated for the 17.7 percent of the community systems (6,019) that did not charge for water and the 15.3 percent (5,188) that could not or did not provide revenue information.

OPERATING AND DEBT RETIREMENT EXPENSES FOR COMMUNITY SYSTEMS

To complete the general description of water system economics, the NSA compiled material on operating and debt retirement expenses. Along with revenues, these two parameters are the most important financial characteristics of all water systems. Relatively large proportions of revenues often are allocated to one or both of these cost categories, and their total occasionally exceeds the amount available for all expenditures. In fact, according to NSA data, 6.2 percent of community systems (1,388) expended more on these cost requirements combined than they collected in revenues, 42.9 percent (9,647 systems) reported costs equal to revenues, while another 40.7 percent (9,152) reported that their revenues were greater than their operating and debt retirement costs. The remaining 10.2 percent (2,299) could not be calculated because one or both of the components was missing.

Systems with costs exceeding revenues are operating at a deficit, and the others are either accumulating a surplus or are at the point where their production expenses correspond to their revenues. Since they are usually of sufficient prominence to distinguish, operating costs will be tabulated first in the following segment, followed by the information on debt retirement.

Operating and maintenance costs

In the NSA, operating costs are restricted to expenditures made in support of operating and maintenance functions. These include expenses for labor, fuel, electricity, chemicals, and other production materials. This particular form of operating expenditures excludes other items that may be considered components of total operating costs such as taxes, depreciation or amortization charges, and accounting and administrative costs. These latter cost factors were not specifically requested, in part, because they were not typically large enough to compile, and also because they were difficult to obtain separately on a systematic basis from all systems. However, some systems may have incorporated these costs in the total operating costs given.

Table VIII-31 presents the annual operating and maintenance costs for community systems. The median cost was $8,000, in contrast to the mean of $118,000. Consistent with the vast differences between the systems, their operating maintenance costs ranged from a minimum of $0 to a maximum of $7.3 million. About 25 percent (24.7 percent, or 8,399) had costs of $1,000 through $5,000, while another 11.7 percent (3,986) reported operating and maintenance costs of between $11,000 and $25,000. Beyond these intervals, 7.7 percent (2,621) stipulated costs of $26,000 through $50,000; 7.7 percent (2,619) had costs of $51,000 through $500,000; and 1.8 percent (603) reported annual expenditures of more than $500,000. At the other extreme, 3.0 percent (1,026) had no annual operating and maintenance costs. The expenditures for operating and maintenance could not be determined for 36.7 percent (12,479) of the systems.

Debt Retirement Costs

Water systems, as alluded to earlier in this chapter, are capital-intensive operations. This dependence on capital makes it necessary for many systems to borrow funds periodically or to assume some other debt obligation. The costs

Table VIII-31

Annual Operating and Maintenance Costs for Community Systems

Amount in Thousands	Number of Systems	Percent of Systems
0	1,026	3.0
1 - 5	8,399	24.7
6 - 10	2,281	6.7
11 - 25	3,986	11.7
26 - 50	2,621	7.7
51 - 100	1,656	4.9
101 - 500	963	2.8
More than 500	603	1.8
Unknown	12,479	36.7
Total	34,014	100.0

Median:	$8,000
Mean:	$118,000
Minimum:	$0
Maximum:	$7.3 million

accompanying this debt load, such as interest expenses, constitute a significant expense for a substantial number of systems, particularly those with appreciable capital requirements.

Information on annual debt costs for community systems is provided in Table VIII-32. The median debt retirement cost was $10, while the mean was $18,500. Similarly, debt retirement costs varied from a low of $0 to a high of $4.0 million. Most importantly, perhaps, 32.8 percent of the community systems (11,162) indicated that they had no annual debt costs, and another 9.4 percent reported that their costs were between $1,000 and $5,000. Towards the upper end of the distribution, 3.3 percent (1,107) had costs of $26,000 through $100,000, while 1.6 percent (558) expended more than $100,000 annually to retire their outstanding debt. Data on annual debt retirement expenditures could not be obtained for approximately 40 percent of the community systems (39.7 percent, or 13,508) that appear in the table.

SUMMARY, COMMUNITY WATER SYSTEMS

Potentially, there are a large number of attributes that may be used to characterize community water systems in terms of their economic condition. The NSA compiled data on those aspects that were judged to be most important to the financial viability of the systems that convey water to rural households. These include (1) initial capital expenditures or the amount of funds expended on the most recent major alteration, (2) the general and particular arrangements for the financing of these activities, (3) revenues from water production, and (4) operating and debt retirement expenses. Usually, the information on these topics was restricted to dollar amounts, except for financing arrangements where more detail was provided. This detail consisted of the source of the capital, the amount of funds acquired, the interest rate on the funds, and the length of any repayment period. The sources encompass internal mechanisms, such as reserve funds or

Table VIII-32

Annual Debt Costs for Community Systems

Amount in Thousands	Number of Systems	Percent of Systems
0	11,162	32.8
1 - 5	3,193	9.4
6 - 10	2,233	6.6
11 - 25	2,253	6.6
26 - 50	737	2.2
51 - 100	370	1.1
More than 100	558	1.6
Unknown	13,508	39.7
Total	34,014	100.0

Median:	$10
Mean:	$18,500
Minimum:	$0
Maximum:	$4.0 million

accumulations of surplus, and external modes of support, such as loans and grants from public entities, municipal bonds, and commercial loans. An effort was also made to establish the relative prominence of each source and the extent to which they subsidize the operations of the community systems considered in this section of the chapter.

Construction costs, which varied substantially across community systems, ranged from a low of $90 to a high of $35.0 million when expressed in 1978 constant dollars. Systems financed these activities with capital secured from internal sources only, external sources only, or a combination of both. When community systems financed capital projects with internally generated funds, the amounts invested tended to be smaller, as was indicated by the median amount of $6,000. When the systems had to sustain a larger requirement for capital, they were inclined to solicit assistance from some external source. Of these external financing mechanisms, loans from government agencies were most prevalent, followed by commercial loans, government agency grants, and municipal bonds.

Community systems that supported capital expenditures with loans and grants from public entities tended to receive them from some organization affiliated with the federal government. State agencies and other public bodies such as special districts or water authorities also were involved in providing loans to rural water systems, while grants were made available by the preceding sources as well as by regional agencies. Of these federal organizations, FmHA was the most prominent source of loans and grants, followed by EDA. Some systems also secured loans or grants from HUD, and a few others received a grant from DOD.

On the average, loans from HUD were the largest, followed by those from FmHA and EDA. Generally, state agencies lent smaller amounts of funds in comparison to the other organizations from which community water systems borrowed capital.

Data on standardized rates indicated that systems with loans from FmHA paid a slightly higher interest rate than systems with loans from EDA or HUD. Although a larger proportion of systems with FmHA loans were being subsidized, a higher percentage of systems that had loans from FmHA appeared to be paying excessive capital costs when the loan repayments were expressed in present value terms.

While they did not provide support to as many systems, grants awarded by other agencies tended to be for larger amounts than those received from the three federal agencies (FmHA, EDA, and HUD). Considering only these three organizations, median grants from HUD and EDA were slightly larger than the median for grants from FmHA. Grants from regional agencies were larger overall than those acquired from the federal organizations, while grants from state agencies were the smallest.

Many community systems supported their capital projects by issuing bonds or securing loans from commercial establishments. The bonds tended to be issued for relatively large amounts, with some exceeding $10.0 million. Standardized interest rates were comparable to those for federal loans, and about the same proportion of systems received a subsidy from the bond-holders. Commercial loans were smaller on the average, and the systems that obtained capital from this source also paid the highest interest rates.

Revenues, similar to the capital expenditures on construction activity, differed substantially across systems that provided the necessary information. Community systems that charged for water reported revenues as low as $400 and as high as $12.0 million. About 18 percent of the systems did not charge for water, and therefore had no water-related revenues. Annual revenues could not be determined for a substantial proportion of the systems.

While they varied appreciably, revenues were occasionally not sufficient to support all expenditures. Fully 6.2 percent of community systems received less in revenue than they allocated to operating and maintenance costs and debt retirement expenses combined. Operating and maintenance costs tended to be substantial, although 3.0 percent of the systems reported that no funds were expended to support these activities. Likewise, debt retirement expenses tended to be small since about 33 percent of the systems did not allocate any money for this cost component. Consistent with the considerable size differences between these systems, some had annual operating and maintenance costs of $7.3 million, while others had debt obligations of $4.0 million. Most significantly, about 37 percent of the systems did not supply information on their operating and maintenance costs, and about 40 percent did not provide data on their debt costs.

INTERMEDIATE WATER SYSTEMS

The emphasis to this point has been on the economics of community water supply systems. Expenditures for initial construction or major alterations of community systems were first detailed, followed by the sources of those funds, interest rates, and repayment periods. Additionally, system revenues, annual operating and maintenance costs, and annual debt costs were reported. Similar information is presented here for intermediate systems but, as stated in the introduction to the chapter, is somewhat abbreviated as a result of data limitations.

As explained in Chapter VII, intermediate systems were often comprised of only two or three connections, were usually informally managed and operated, and were most often owned by individuals either residing in the sampled household or living in an adjacent dwelling. These systems generally required little or no maintenance, as indicated by the prevalence of one or fewer operators and the fact that usually less than one man-day per month was required for operation. Given this profile, it was anticipated that intermediate systems would more often rely upon reserve funds for initial construction and improvements to the supply, rather than seeking the wide variety of funding sources available and used by community systems.

CONSTRUCTION COSTS FOR INTERMEDIATE SYSTEMS

The NSA solicited information on the cost of construction, regardless of whether the activity involved the original installation of the system, or simply represented the most recent major alteration to the system. As explained earlier, a major alteration may have involved a relatively inexpensive improvement such as replacing a malfunctioning pump, or may have involved a more costly modification such as expanding the processing or service facilities of the system. Information on the cost of construction is presented in Table VIII-33 and these dollar amounts are expressed in 1978 dollars (see Construction costs for community systems for discussion of standardization).

Construction costs for intermediate systems varied considerably, from a minimum of $20 to a maximum of $1.5 million. However, as indicated by the median and mean ($1,400 and $5,100, respectively), the distribution included several high values which tended to inflate construction costs among intermediate systems. In fact, as shown in Table VIII-33, only 4.5 percent of these systems (38,000) reported costs in excess of $5,000. At the other end of the distribution, 3.7 percent (31,000) expended less than $100 to modify the system. More significantly, however, was the finding that 42.2 percent (357,000) of all intermediate systems could not or did not provide construction cost information, and therefore caution is advised when interpreting the results presented here. This lack of information can be attributed to a number of factors: these systems had no knowledge of their costs, did not maintain complete financial records, or the system informants refused to respond when asked this particular question.

A comparison of community system and intermediate system construction costs showed, not unexpectedly, that the latter were significantly less. Despite

Table VIII-33

Construction Costs for Intermediate Systems in Constant 1978 Dollars

Cost in 1978 Dollars	Number of Systems	Percent of Systems
Less than $100	31,000	3.7
$100 - $299	47,000	5.6
$300 - $499	58,000	6.9
$500 - $999	61,000	7.2
$1,000 - $1,499	70,000	8.3
$1,500 - $1,999	45,000	5.3
$2,000 - $2,999	72,000	8.5
$3,000 - $3,999	44,000	5.2
$4,000 - $4,999	22,000	2.6
$5,000 or more	38,000	4.5
Unknown	357,000	42.2
Total	845,000	100.0

Median:	$1,400
Mean:	$5,100
Minimum:	$ 20
Maximum:	$1.5 million

similar minimum costs ($90 for community systems, $20 for intermediate systems), the maximum cost in 1978 dollars was $35.0 million among community systems and only $1.5 million among intermediate systems. Though the median cost differed by only a factor of 10 ($1,400 and $14,000), average construction costs among community systems were roughly 50 times as large ($270,000, compared to $5,100). Finally, although the amount of missing information was sizeable among all multiple connection systems, it was considerably greater among systems of from two through fourteen connections than among those with fifteen or more connections (42.2 percent, compared to 25.1 percent).

GENERAL FINANCING SOURCES FOR INTERMEDIATE SYSTEMS

Since intermediate systems are small in scale, the opportunitites for securing funds may be severely limited, in accordance with the reduced size of the rural population served. For instance, although government agencies (in particular, the Farmers' Home Administration) provide support to rural water systems, preferences are usually given to community systems that quality for assistance, and that serve a larger proportion of the rural community. Hence, intermediate systems were more likely to rely on "out-of-pocket" expenditures (reserve funds) or loans secured through financial institutions, at undoubtedly considerable cost.

In the NSA, sources of financing were tabulated according to whether the source was internal, external, or a combination of the two. Of the systems that could provide information on the amount of the construction activity as well as the year in which it was accomplished, nearly 28 percent (136,000) could not or did not provide information on the source of financing (Table VIII-34). About two-thirds of the systems, however, indicated that their construction costs were financed by internal sources exclusively. Another 6.0 percent of the systems (29,000) used some external source exclusively, while only 0.1 percent (700) obtained financing from a combination of internal and external sources.

Table VIII-34

Use of Internal and External Financing for Construction of Intermediate Systems

Source of Financing	Number of Systems	Percent of Systems
Internal only	321,000	65.9
External only	29,000	6.0
Both	700	0.1
Could not be determined	136,000	27.9
*Total	488,000	99.9

*Table includes all intermediate systems that could supply information on both construction costs and date of completion.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

The sources of community and intermediate water system financing was similar, but the proportions obtaining financial assistance through internal sources, external sources, or a combination of the two, were quite dissimilar. Though the predominant source of financing for all multiple connection systems was internal sources only, this source was used by about 66 percent of intermediate systems and 47 percent of community systems. Comparable proportions for external financing only were 6.0 percent and 39.2 percent, respectively, and proportions for both sources of financing were 0.1 percent and 9.7 percent, respectively.

In summary, although both community and intermediate systems are more dependent upon internal sources for financing water system development, external sources or a combination of internal and external sources are available and used. However, external sources of financing (either exclusive or in combination) account for a very small proportion of the total among intermediate systems serving rural America.

Internal financing sources for intermediate systems

Internal sources of financing include reserve funds, profits, and accumulated earnings, but in the case of the conventional two- or three-connection intermediate system, this source probably refers to an individual's savings. The principal advantage of expending funds produced by internal sources is that there is no debt encumbered, although this may mean that capital is diverted from perhaps a more profitable investment.

The distribution of funds invested from internal sources is provided in Table VIII-35. These amounts, which are expressed in constant 1978 dollars, ranged from a minimum of $20 through a maximum of $63,000. Similar to the information presented on construction costs for all intermediate systems, the median amount invested from internal sources was $1,200 (as compared to $1,400). Unlike the earlier distribution, however, the average amount invested from internal sources

Table VIII-35

Amount Invested from Internal Sources
(Constant 1978 Dollars)

Amount in 1978 Dollars	Number of Systems	Percent of Systems
Less than $100	31,000	9.6
$100 - $299	31,000	9.6
$300 - $499	37,000	11.4
$500 - $999	46,000	14.3
$1,000 - $1,499	37,000	11.3
$1,500 - $1,999	29,000	9.1
$2,000 - $2,999	39,000	12.2
$3,000 - $3,999	33,000	10.1
$4,000 - $4,999	14,000	4.3
$5,000 or more	24,000	7.4
Unknown	2,000	0.6
Total	322,000	99.9

Median:	$ 1,200
Mean:	$ 2,100
Minimum:	$ 20
Maximum:	$63,000

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

was much lower, about $2,100 (compared to $5,100). This finding suggests that internal sources were used to support construction activities that were modest in scale when compared to external or combination sources of financing which comprised the balance of construction costs appearing in Table VIII-33.

An examination of the categories in Table VIII-35 shows a fairly even distribution of systems which expended less than $100 of accumulated earnings on construction activities through $3,000 to $3,999. The proportion of intermediate systems falling in these categories varied from about 9 percent through 12 percent, except for the somewhat larger proportion (14.3 percent) which invested between $500 and $999. Only 4.3 percent of the systems invested between $4,000 and $4,999, and another 7.4 percent that employed internal sources, expended $5,000 or more for original construction or modification to the existing system.

A comparison of community system and intermediate system investments derived from internal sources showed that the former were considerably larger than the latter. Specifically, the average amounts allocated to water system development by community systems and intermediate systems were $25,000 and $2,100, respectively.

External financing sources for intermediate systems

Despite the limited availability of external sources of financing, NSA results did show that a number of intermediate systems were able to secure government loans and grants, as well as loans from financial institutions. Though municipal bonds were not among the list of external sources, this does not necessarily mean that intermediate systems do not issue bonds; it probably means that they were not frequent enough to have been included in the sample.

Table VIII-36 presents information on the number and percent of intermediate systems that reported acquiring financial support from each of these three external capital sources. Of the 30,000 systems which acquired external funds, the

Table VIII-36

External Sources of Financing For Construction of Intermediate Systems

Source of Financing	Number of Systems	Percent of Systems
Government agency loans	11,000	37.1
Commercial loans	18,000	59.8
Government agency grants	900	3.1
*Total	30,000	100.0

*Table includes 29,000 systems with only external sources of financing, and 700 systems with both internal and external sources.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

largest proportion (59.8 percent, or 18,000 systems) obtained commercial loans to finance their construction activity. Government agency loans were another prominent source of construction capital (secured by 37.1 percent, or 11,000 systems), but government grants were used by only 3.1 percent of the 30,000 intermediate systems that secured external funds.

External sources of financing among community systems showed a similar pattern, with loans secured from either government organizations or banks as the most prevalent mode of external financing. However, unlike community systems, which often used municipal bonds to finance construction activities, intermediate systems did not utilize this funding source.

Public financing sources for intermediate systems

Public financing of intermediate water systems is very limited in scope as indicated by Table VIII-37 which presents information on the levels of government involved in water system financing. The federal government and an unspecified agency provided loans to only 11,000 intermediate water systems and provided grants to only 900 of these small systems.

Though few intermediate systems received funds for construction from public sources, four distinct federal agencies were involved in this support. As shown in Table VIII-38, the Farmers' Home Administration (FmHA) and the Department of Defense (DOD) made loans available for initial construction or major alteration of small water systems, while the Department of Housing and Urban Development (HUD) and the Economic Development Administration (EDA) provided assistance in the form of grants. Since the estimated 8,000 systems receiving federal loans are based on only two intermediate systems appearing in the NSA sample, information on the amount of these loans, interest rates, and repayment periods are not presented. Likewise, since the estimated 900 systems

Table VIII-37

Public Sources of Financing for Construction of Intermediate Systems

Source of Financing	Number of Systems	Percent of Systems
Loans		
Federal	8,000	74.1
Unknown	3,000	25.9
Total	11,000	100.0
Grants		
Federal	900	100.0
Total	900	100.0

Table VIII-38

Federal Sources of Financing for Construction of Intermediate Systems

Source of Financing	Number of Systems	Percent of Systems
Loans		
FmHA	5,000	57.9
DOD	3,000	42.1
Total	8,000	100.0
Grants		
HUD	900	100.0
EDA	900	100.0
*Total	900	100.0

*Total of percentages exceeds 100 percent because a single system in the NSA sample obtained grants from more than one federal agency.

are really based on a single observed intermediate system in the NSA sample, the amount of grant awarded is not detailed here.

Private financing sources for intermediate systems

Loans from commercial institutions are a widely available source of private capital, but usually entail considerable expense. Perhaps this was the reason that only a small number of intermediate systems (18,000) sought this type of assistance. The information compiled in the NSA consisted of data on the amounts of these commercial loans and their interest rates. As before, the amount of loans obtained from financial institutions are expressed in constant 1978 dollars, while the interest rates are standardized so that meaningful comparisons can be made.

The amount of capital borrowed from banks ranged from a minimum of roughly $600 through a maximum of about $15,000 (Table VIII-39). The median amount was $2,300, nearly twice the amount allocated to construction activities from reserves. Over three-quarters of the systems which secured commercial loans received funds amounting to less than $4,000. The average loan amount was about $1,000 more than the median, approximately $3,300. Few systems (2,000, or 8.4 percent) obtained loans in excess of $10,000.

Information on the annual interest rates for commercial loans is presented in Table VIII-40. The rates ranged from a minimum of 6.0 percent to a maximum of 10.5 percent. Both the average and median rates of interest on commercial loans were 7.7 percent. Surprisingly, the median and mean commercial rate of interest fell below the long term government bond yield of 7.89 for 1978, however slightly. Since commercial institutions normally establish rates which exceed the long term government bond yield, this may mean that water systems are securing funds from private individuals at a lower rate of interest.

Table VIII-39

Amount of Loans Obtained from Financial Institutions (Constant 1978 Dollars)

Amount in 1978 Dollars	Number of Systems	Percent of Systems
Less than 2,000	5,000	26.6
2,000 - 3,999	9,000	51.7
4,000 - 5,999	1,000	6.8
6,000 - 7,999	700	4.0
8,000 - 9,999	500	2.5
10,000 or more	2,000	8.4
Total	18,000	100.0

Median:	$ 2,300
Mean:	$ 3,300
Minimum:	$ 600
Maximum:	$15,000

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Table VIII-40

Annual Standardized Interest Rates on Loans Received from Financial Institutions

Standardized Interest Rate	Number of Systems	Percent of Systems
6.0% - 6.9%	4,000	22.3
7.0% - 7.9%	5,000	28.6
8.0% - 8.9%	8,000	43.3
9.0% or more	1,000	5.8
Total	18,000	100.0

Median:	7.7%
Mean:	7.7%
Minimum:	6.0%
Maximum:	10.5%

A comparison of community system and intermediate system financing showed that not only were the amounts of commercial loans considerably higher for community systems, but so were the interest rates paid on these loans. Considering the loan dollars first, the median community-system loan was $18,000, while the median intermediate-system loan was $2,300. The minimum and maximum amount community systems secured from commercial institutions were $250 and $16.4 million, respectively. Comparable figures for intermediate-system loans were $600 and $15,000, as reported earlier. Although a few community systems were able to secure interest-free commercial loans, the average interest rate paid in 1978 on these loans (9.8 percent) was substantially higher than both the long term government bond yield (7.89 percent) and the average rate paid by intermediate systems (7.7 percent).

INTERMEDIATE SYSTEM REVENUES

The NSA collected data on revenues generated solely from provision of water service. This information was to be an approximation of last year's sales (the year prior to the NSA survey). In some instances, however, it was impossible to obtain the necessary information on annual water-related revenue.

Annual revenues for intermediate water systems are presented in Table VIII-41. As would be expected, given the informal nature of these small systems, the most significant finding was that 93.5 percent of all intermediate systems (790,000) reported no revenues. This finding suggests one of three things: that the service was provided at no cost, or that the system owner, rather than his customers, encumbered the debt associated with operation and maintenance of the system, or that fees may have been collected on a sufficiently irregular basis that they were not defined as an annual revenue. Among the 36,000 systems which collected revenues, the majority (20,000) reported revenues between $1 and $100.

Table VIII-41

Annual Revenues for Intermediate Systems

Amount	Number of Systems	Percent of Systems
No charge for water	790,000	93.5
$1 - $100	20,000	2.3
$101 - $300	9,000	1.1
$301 - $750	6,000	0.7
More than $750	1,000	0.1
Unknown	19,000	2.3
Total	845,000	100.0

A very small proportion (0.1 percent, or 1,000 systems) reported revenues in excess of $750, and at least one system reported an annual revenue of $1,500.

OPERATING AND DEBT RETIREMENT EXPENSES FOR INTERMEDIATE SYSTEMS

In the NSA, annual operating and maintenance costs and debt retirement costs were expressed as proportions of total revenues and therefore were only obtained for systems which reported annual revenues. Since only 36,000 intermediate systems reported any revenue at all, the data on operating costs are obviously somewhat limited, but are presented nevertheless. Information on operating costs are tabulated first, followed by the information on debt retirement costs.

Table VIII-42 presents the annual operating and maintenance costs for intermediate systems. The largest proportion of these systems which collected revenues (40.3 percent, or 15,000) did not allocate any funds to operation and maintenance. An additional 30.6 percent (11,000) had costs of $1 through $99, 8.3 percent (3,000) had costs of $100 through $199, and 13.3 percent (5,000) had costs from $200 through $299. Few intermediate systems (7.6 percent, or 2,000) allocated $300 or more to operation and maintenance in a given year.

As can be seen in Table VIII-42, few systems were retiring any debt. More specifically, 87.7 percent (32,000) had no debt costs, 1.6 percent (600) had costs of $1 through $199, and 1.7 percent (600) had debt costs of $200 or more. Data on annual debt retirement expenditures could not be obtained for fully 9.0 percent of the intermediate systems (3,000) that appear in the table. According to information presented earlier, a much larger number of intermediate systems have debt obligations, but do not appear in Table VIII-42 because they either had no revenues and therefore were not asked about debt costs, or they had completely retired their debt before 1977, the year preceding the survey.

Table VIII-42

Annual Operating and Maintenance Costs and Debt Costs for Intermediate Systems

Amount	Number of Systems	Percent of Systems
O & M Costs		
$0	15,000	40.3
$1 - $99	11,000	30.6
$100 - $199	3,000	8.3
$200 - $299	5,000	13.3
$300 - $399	1,000	3.5
$400 or more	1,000	4.1
*Total	36,000	100.1
Debt costs		
$0	32,000	87.7
$1 - $199	600	1.6
$200 or more	600	1.7
Unknown	3,000	9.0
*Total	36,000	100.0

*Table includes all intermediate systems that reported annual revenues.

Each figure in the table is rounded independently; numbers and percentages may not equal rounded totals.

Operating and maintenance costs differed appreciably among community and intermediate systems. For one thing, nearly 37 percent of community systems could not provide information on the subject, while all intermediate systems which reported revenues could provide the necessary data. A second point of comparison showed that while only 3.0 percent of community systems had no operating costs during the year prior to the survey; the comparable proportion for intermediate systems was about 40 percent. Lastly, operating and maintenance costs were substantially higher in community-system operations. The median cost among community systems was about $8,000, compared to less than $100 among intermediate systems.

Annual debt costs were similar for both types of multiple-connection systems in the sense that median costs were near $0. However, community-system annual debt costs reached $4.0 million, while intermediate-system debt costs did not exceed $750.

SUMMARY, INTERMEDIATE WATER SYSTEMS

Unlike community water systems, there was only a limited amount of information available to describe the economic condition of intermediate water systems. This lack of information can be attributed to the often informal organizational arrangements of these systems. In fact, in many ways, intermediate systems more often resembled individual systems—in their financing arrangements, in their operation, in the amount of maintenance required, and so forth—than they did community systems. For this reason, comparisons between intermediate systems and community systems are not drawn here, although they appear throughout the preceding section of this chapter.

In terms of the data that were compiled on the economics of intermediate water supply systems, initial capital expenditures or the amount of funds expended on the most recent alteration were detailed first. Next, information was presented on the types of financing utilized by intermediate systems, and when available, the amount of the funds and the interest rates. Finally, though somewhat abbreviated, findings on revenues from water production, and operation and debt retirement expenses were provided.

Construction costs, which varied substantially across intermediate systems, ranged from a low of $20 to a high of $1.5 million when expressed in 1978 constant dollars. Average costs were about $5,100, while the median of the distribution centered on $1,400. Construction activity among intermediate systems was mainly financed through reserve funds (about 66 percent), although assistance was sometimes secured from an external source (6 percent), or a combination of internal and external sources (less than 1 percent). The source of financing could not be determined for the remaining 28 percent.

The amounts of capital invested from internal sources were not as wide-ranging when compared to construction costs without regard to the specific source of financing. These internal amounts, which are also expressed in 1978 constant dollars, ranged from a minimum of $20 through a maximum of $63,000. The median amount invested from internal sources was $1,200, while the average amount invested was about $2,100.

Among the 30,000 intermediate systems that received external monies for water system development, funds were most often secured from commercial establishments (about 60 percent), but were sometimes obtained from federal agencies in the form of loans (about 37 percent) or grants (about 3 percent). Commercial financing was modest in scale, ranging from $600 through about $15,000. The mean and median amounts borrowed from banks ($3,300 and $2,300, respectively) were somewhat larger than the comparable amounts invested from internal sources (see above). The amounts of funds secured from federal agencies were not detailed here or elsewhere, since only three intermediate systems appearing in the NSA sample were involved.

As to water-related revenues, the most significant finding was that fully 93.5 percent of all intermediate water systems did not charge for the provision of water. Those that did, reported revenues between $1 and $1,500, although only a few systems claimed revenues in excess of $100. Likewise, operation and maintenance costs rarely exceeded $100. However, a substantial proportion of systems (40 percent) which reported revenues indicated that, at least during the year preceding the NSA survey, no funds were expended to support operation and maintenance activities. Finally, few intermediate systems were retiring any debt. Among those that reported annual revenues, about 88 percent had no debt costs; 9 percent could not provide any information on this cost component; and for the few systems that allocated a proportion of annual revenues to debt retirement, small amounts were expended.

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